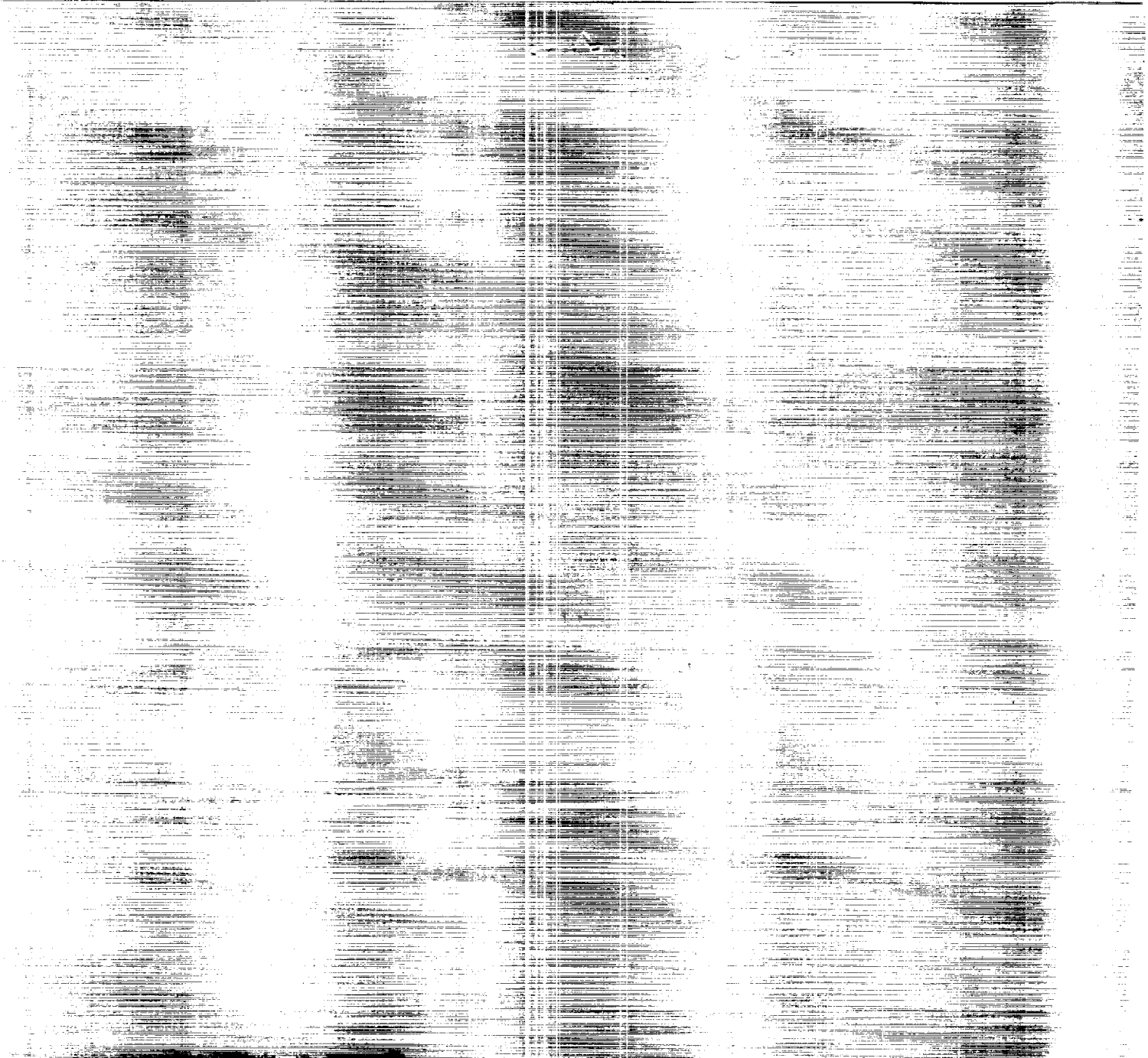


Available through the NASA Scientific and Technical Information Facility, P.O. Box 8757, BWI Airport, MD 21240.

INTRODUCTION

This publication represents the NASA research and technology program for FY 1988. It is a compilation of the "Summary" portions of each of the RTOPs (Research and Technology Objectives and Plans) used for management review and control of research currently in progress throughout NASA. The *RTOP Summary* is designed to facilitate communication and coordination among concerned technical personnel in government, in industry, and in universities. We believe also that this publication can help to expedite the technology transfer process.

The *RTOP Summary* is arranged in five sections. The first section contains citations and abstracts of the RTOPs. Following this section are four indexes: Subject, Technical Monitor, Responsible NASA Organization, and RTOP Number.

The Subject Index is an alphabetical listing of the main subject headings by which the RTOPs have been identified.

The Technical Monitor Index is an alphabetical listing of the names of individuals responsible for the RTOP.

The Responsible NASA Organization Index is an alphabetical listing of the NASA organizations which developed the RTOPs contained in the Journal.

The RTOP Number Index provides a cross-index from the RTOP number assigned by the responsible NASA organization to the corresponding accession number assigned sequentially to the RTOPs in *RTOP Summary.*

As indicated above, responsible technical monitors are listed on the RTOP summaries. Although personal exchanges of a professional nature are encouraged, your consideration is requested in avoiding excessive contact which might be disruptive to ongoing research and development.

Any comments or suggestions you may have to help us evaluate or improve the effectiveness of the *RTOP Summary* would be appreciated. These should be forwarded to:

National Aeronautics and Space Administration
Office of Aeronautics and Space Technology
Washington, D.C. 20546
Attn: Edmund L. Sanchez
Director, Resources and Management
Systems Office (RB)

William F. Ballhaus, Jr.
Acting Associate Administrator for
Aeronautics and Space Technology

TABLE OF CONTENTS

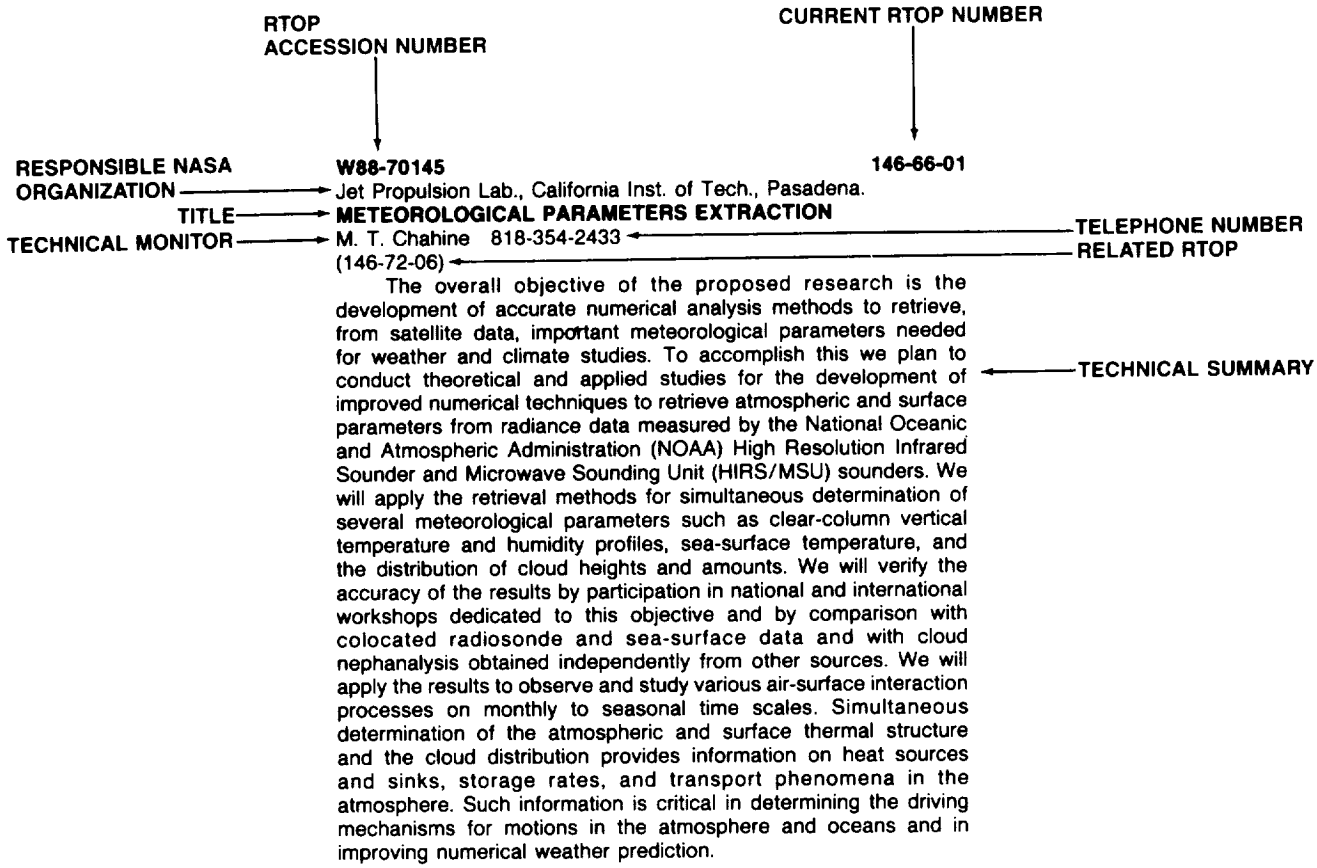
PAGE

Office of Space Science and Applications

Office of Space Tracking and Data Systems

Indexes

TYPICAL CITATION AND TECHNICAL SUMMARY



RESEARCH AND TECHNOLOGY OBJECTIVES AND PLANS

a summary

FISCAL YEAR 1988

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

Aeronautics Research and Technology Base

Fluid and Thermal Physics Research and Technology

W88-70001 **(23) 505-60**
Langley Research Center, Hampton, Va.
FLUID AND THERMAL PHYSICS RESEARCH AND TECHNOLOGY
R. V. Harris 804-865-3285

The objective is to advance the computational and experimental state of the art in a broad range of fundamental technology areas and to promote the synergistic evolution of innovative, high-risk concepts and technologies needed for the efficient design of advanced civil and military aircraft. Solution methodology will be developed for a variety of viscous and inviscid equation sets including the full Navier-Stokes equations and applied to increasingly complex configurations, as well as flow stability problems, across the speed range from subsonic to hypersonic. Detailed critical experiments will be performed to validate new computational methods and to improve the fundamental understanding of complex fluid physics and chemistry processes. This improved understanding will be applied to the development and evaluation of innovative concepts for reducing aircraft drag. Improved aircraft design methodology will be validated using data from flight tests, from numerous ground facilities, and from the high Reynolds number data base being generated in the National Transonic Facility.

W88-70002 **(10) 505-60**
National Aeronautics and Space Administration, Washington, D.C.
FLUID AND THERMAL PHYSICS RESEARCH AND TECHNOLOGY
Leslie J. Chow 202-453-8781
(505-61-00; 505-65-00; 506-40-00)

The objectives are to enhance technology transfer between researchers and end-users of NASA-developed computational research and foster research activity in technical areas of interest. In particular, grid generation concepts such as solution-adaptive gridding and local error assessment are stressed. A conference on numerical grid generation will be jointly funded by NASA and AFOSR. NASA is represented on the conference organizing committee. The University of Miami will handle conference arrangements. The conference will be held on 5-6 December 1988.

W88-70003 **(55) 505-60**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FLUID AND THERMAL PHYSICS RESEARCH AND TECHNOLOGY
L. M. Mack 818-354-2138

This work applies to the research area of laminar instability and transition. The overall objective is an understanding of the detailed physical processes that lead to boundary-layer transition, and the application of this knowledge to the prediction of transition. The plan is to use experimental, analytical and numerical techniques to investigate the following four problems: (1) the mechanism by which instability waves are produced by various external disturbance sources, and the determination of their initial conditions (receptivity problem); (2) the propagation of the resultant instability wave trains and wave packets through the boundary layer to the point where turbulence first appears; (3) the development of a rational method for the prediction of transition; and (4) passive and active methods of transition control. As knowledge of transition is important for aircraft performance in all speed ranges and for all aerodynamic surfaces, the research will encompass two- and three-dimensional incompressible, transonic, supersonic and hypersonic boundary layers.

W88-70004 **(21) 505-60**
Ames Research Center, Moffett Field, Calif.
FLUID AND THERMAL PHYSICS RESEARCH AND TECHNOLOGY
P. Atkins 415-694-4007
(505-61-00; 505-65-00; 506-40-00)

The objective is to advance fundamental understanding of basic aerodynamic and thermodynamic processes and to develop predictive capabilities for analysis and design optimization of advanced aerospace vehicles and their propulsion systems. A combination of computer simulations and experiments will be used to study flow over individual aerospace vehicle components, as well as complete configurations. New algorithms, languages, and compilers will be constructed to realize the most effective use of advanced computer systems. Computer programs will be developed to simulate turbulence and to solve fluid dynamics problems, including the effects of viscosity and unsteady flow. Computer codes applicable to practical fluid dynamics problems will be developed to transfer advanced technology to the aerospace community. Experiments will be performed for a large Reynolds number range to document detailed turbulence properties and to provide turbulence models for use in solutions of the Reynolds-averaged Navier-Stokes equations. Both wind tunnel and flight experiments will be conducted to verify computer simulations and to validate prediction techniques.

Applied Aerodynamics Research and Technology

W88-70005 **(23) 505-61**
Langley Research Center, Hampton, Va.

APPLIED AERODYNAMICS RESEARCH AND TECHNOLOGY
R. V. Blankenship 804-865-3285

The objective is to develop an advanced and validated base of new aerodynamics technology for application to future generations of civil aircraft, rotorcraft, and fighter aircraft. An additional objective is to accelerate technology development in support of the hypersonic cruise/transatmospheric vehicles. Ground-based, flight, and computational facilities are used to generate the advanced technology needed to accomplish the cited objectives. Wind-tunnel tests and consultation to DOD, industry, and other agencies are provided consistent with available resources.

W88-70006 **(21) 505-61**
Ames Research Center, Moffett Field, Calif.
APPLIED AERODYNAMICS RESEARCH AND TECHNOLOGY
B. A. Lampkin 415-694-6039
(505-60-00; 763-01-00)

The overall objective of this activity is to provide the necessary research and technology development for an improved validated base of new aerodynamics technology for application by industry to future generations of both civil and military flight vehicles. The approach will be to conduct analytical, ground based, and flight research investigations of a broad class of vehicles, which shall include subsonic transport and general aviation aircraft, rotorcraft, advanced fighter/attack aircraft, powered lift configurations (STOL, V/STOL and STOVL) and hypersonic vehicles. This RTOP includes the development of wind tunnel instrumentation.

W88-70007 **(55) 505-61**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
APPLIED AERODYNAMICS RESEARCH AND TECHNOLOGY
V. Sarohia 818-354-6758

The near term objective of this research effort is to apply the non-intrusive multi-point velocity measurement technique in water to study unsteady flow over a pitching airfoil. In particular, this digital image processing technique under development will be utilized to: (1) provide physical understanding of the dynamic stall; (2) determine cause of delay of boundary layer separation; and (3) explore effect of various pitching parameters on delay of stall. The long-range objective is to continue to develop the non-intrusive technique to make automated multi-point velocity measurements utilizing digital image processing on ground with potential application in free flight.

Propulsion and Power Research and Technology

W88-70008 **(22) 505-62**
Lewis Research Center, Cleveland, Ohio.
PROPULSION AND POWER RESEARCH AND TECHNOLOGY
J. A. Ziemianski 216-433-3901

The broad objective is to explore and develop the technologies for the propulsion systems of advanced VSTOL, supersonic and hypersonic cruise aircraft, rotorcraft, and smaller conventional aircraft. In-house, contract, and grant research and development efforts will address various components such as inlets, engines, nozzles, ejectors, fans, and helicopter transmissions as well as unique propulsion systems and propulsion/airframe integration. Improved instrumentation and controls will be developed, and internal computational fluid mechanics capabilities will be enhanced by test and analysis.

W88-70009 **(23) 505-62**
Langley Research Center, Hampton, Va.
PROPULSION AND POWER RESEARCH AND TECHNOLOGY
R. V. Harris 804-865-3285

Advanced experimental and analytical techniques are used to develop all technology areas for airbreathing hypersonic propulsion concepts, to develop the technology to significantly improve the performance potential of hypersonic flight vehicles including an understanding of and solutions to problems inherent to such vehicles, and to provide basic information on the effect of advanced propulsion concepts on the performance and interference characteristics of advanced aircraft. Analytical and experimental studies using advanced facilities and techniques are utilized by unique personnel to investigate scramjet engine components, complete subscale engines, problems inherent to such engines, engine/airframe integration and improvement of hypersonic aerodynamic performance. In addition, advanced aircraft configurations and generic models are used for investigations of thrust vectoring and reversing, 2-D nozzles and propulsion control, and nacelle/wing interactions. Computational methods and unique experimental procedures are developed to help understand the flow phenomena associated with hypersonic propulsion and inlet and nozzle integration.

Materials and Structures Research and Technology

W88-70010 **(23) 505-63**
Langley Research Center, Hampton, Va.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
C. P. Blankenship 804-865-2042

This research includes executing analytical and experimental programs in structures, materials, and acoustics with emphasis on: (1) thermal structures, aeroelasticity, unsteady aerodynamics, and aeroservoelasticity; (2) structural mechanics and landing dynamics; (3) polymeric materials, metallic materials, and composite materials; (4) aeroacoustics and structural acoustics; and (5) interdisciplinary analysis and optimization. Principal research objectives include providing structures and materials technologies that will enhance the performance, efficiency, and reliability of advanced commercial, military, and general aviation aircraft. Analytical, computational, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry.

W88-70011 **(21) 505-63**
Ames Research Center, Moffett Field, Calif.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
H. G. Nelson 415-694-6700

The overall objective is to provide the materials, structures, and acoustics research and technology development necessary for significant improvements in the performance, durability, utility, and economy of future generation civil and military aircraft. Fundamental experimental and analytical research on advanced composites will be performed to better characterize and understand fatigue and fracture behavior in order to predict accurately the service life of structures when exposed to their environments. Aeroelastic characteristics of new vehicle configurations (X-29A, etc.) will be investigated, new flight load and deflection measurement techniques developed, and analysis codes evaluated through correlation with measured values. In the generic hypersonic area efforts will be directed toward the development, fabrication, and evaluation of lightweight ceramic matrix composite structural concepts for airframe and heat shielding of hypersonic flight vehicles; development of the capability of elevated temperature mechanical testing in aggressive chemical environments; modelling and understanding the interaction zone existing between the metal-fiber contact surfaces in an advanced metal-matrix composite; and developing knowledge and skills in analyzing and testing structural concepts requiring active cooling by liquid hydrogen, liquid methane, and other cryogens.

W88-70012 **(22) 505-63**
Lewis Research Center, Cleveland, Ohio.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
S. J. Grisaffe 216-433-3193
(535-00-00; 505-66-00)

The first major objective of this RTOP is to advance the level of materials and processing technologies for high-temperature metallic, polymeric, and ceramic materials in order to contribute to improving the performance, life, reliability, structural efficiency, and/or to reducing the cost of future turbine engines. The prime emphasis of the work is directed toward developing greater understanding of the interrelationships between material composition and microstructure, fabrication processes, and mechanical/physical properties. The second major objective is to develop and verify advanced analysis and synthesis methods, advanced generic structural concepts, and advanced quantitative life prediction capabilities applicable to high temperature aerospace propulsion components; and in addition, to develop and experimentally validate improved analytical methods to describe and predict the dynamic and aeroelastic response of aircraft turbine engine systems. Emphasis will be on high temperature applications. Material behavior constitutive relations will be developed emphasizing anisotropy of metallic/ceramic/composite materials. Generic structural concepts will be conceived to exploit the capabilities of advanced material systems.

W88-70013 **(10) 505-63**
National Aeronautics and Space Administration, Washington, D.C.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
Samuel L. Venneri 202-453-2760

The objective is to conduct fundamental research on advanced materials concepts for aeronautics. Advisory services to guide research and development in advanced aerospace materials are provided by the National Materials Advisory Board, a unit of the National Academies of Science and Engineering. The interdisciplinary program in metal matrix and carbon/carbon composites includes research into the properties of the constituent fibers and matrix materials, advanced structural analysis methods, fatigue response, environmental response, modeling and processing science for light weight airframe structures. The interdisciplinary program in high temperature engine materials focuses on metal matrix composites and ceramic matrix composites. Emphasis will be placed on understanding the processing and properties of these materials. Key activities include the development of high temperature fibers, composite micromechanics at high temperature including time-dependent behavior such as fatigue and creep, and the characterization and control of the fiber/matrix interface for both metal matrix composites and ceramic matrix composites.

Information Sciences Research and Technology

W88-70014 **(62) 505-65**
Marshall Space Flight Center, Huntsville, Ala.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
G. D. Cassimus 205-544-1560

The objective of this effort is to obtain a complete end-to-end high speed mainframe Computer Networking Subsystem (CNS) including its operation and maintenance utilizing the Program Support Communications Network (PSCN) as the communications medium. This subsystem is to provide for the sharing of unique mainframe computational capabilities embodied in the various large scientific computers located at NASA Centers. CNS must be adaptable to changes in the volume of traffic, number of mainframes at each site, mainframe operating systems, number of sites and rate of data transfer. The initial system will link the unique computational capabilities of the OAST Centers. The system to support this link will consist of data buffering and mainframe interface equipment, and utilize the NASA PSCN as the communications medium.

W88-70015 **(21) 505-65**
Ames Research Center, Moffett Field, Calif.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
M. C. Arnold 415-694-5188
(506-44-00)

The objective is to support computational fluid dynamics (CFD), computational chemistry, and other disciplines of agency interest by developing an understanding of the relationships and tradeoffs between algorithms and computer architectures for these applications. Approaches, techniques, and tools are needed to apply this insight to the development of optimal hardware/software systems for this class of problems. The research will permit better utilization of emerging concurrent processors, and will influence the design of systems crucial to NASA in the 1990s. The approach involves collaboration of the Computational Research Branch and Research Institute for Advanced Computer Science (RIACS). This collaboration will bring together computer science and computational physics expertise to analyze the requirements, evaluate extant concepts and products, and conduct the necessary research and development. The steps involved include: the development of requirements and evolution of promising systems concepts; simulation, emulation, or modeling techniques to validate system concepts; and the building of prototypes to serve as proof of concept.

W88-70016 **(23) 505-65**
Langley Research Center, Hampton, Va.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
J. F. Creedon 804-865-4915

Advanced computer architectures offer increased performance and greater reliability. The concurrent processing research under this RTOP addresses both systems issues and distributed operating systems technology to improve performance and reliability. A disciplined approach to software development and automated tools is needed to construct reliable software for flight crucial systems. The software engineering research aims to characterize and evaluate automated support tools for software specification, design, and code; create guidelines for developing fault-tolerant software; and measure software reliability. Concurrent processing issues to be studied include communication and synchronization, programming languages and environments, problem decomposition and algorithm development, and comparison of prototype architectures for real-time computing. Promising distributed operating system concepts will be installed in a laboratory network environment for proof of concept tests. Analysis of fault-tolerant software techniques applied to a realistic flight software problem will be conducted and automatic generation of selected programming constructs studied. Much of the parallel computing systems research will be done at the Institute for Computer Applications in Science and Engineering. A block grant in computer science at the University of Illinois Computing Laboratory for Aerospace Systems and Software supports related research tasks.

Controls and Guidance Research and Technology

W88-70017 **(23) 505-66**
Langley Research Center, Hampton, Va.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
J. F. Creedon 804-865-4915

The overall objective of this work is to provide for the necessary research and technology development leading to improved civil and military aircraft operations under all weather conditions and for the exploitation of new controls and guidance concepts and hardware to increase the efficiency, effectiveness, and safety of

new military and civil aircraft. Research activities under this RTOP will be directed toward establishment of a technology base for multidisciplinary control law analysis and synthesis techniques, improved display design concepts, flight crucial systems, super-maneuverability controls and pilot interface technology, detection, and avoidance of wind shears, and system concepts and procedures enabling safe and efficient operations in the evolving National Airspace System. Analytical and experimental techniques will be developed to exploit advanced electronic and computer based flight systems concepts for improving efficiency and performance of future civil and military aircraft. Emphasis will be placed on increasing levels of integration and on exploiting multi-disciplinary interactions.

W88-70018 **(51) 505-66**
Goddard Space Flight Center, Greenbelt, Md.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
D. G. Roberts 804-824-1541

The overall objective is to provide for operational support to approved OAST projects utilizing the Goddard Space Flight Center/Wallops Flight Facility (GSFC/WFF) research airport. Operational support includes: project coordination; program aircraft fuel and ground servicing; control tower management of the GSFC/WFF research airport control area; airport maintenance; shop support; ADP operations; SAR, chase, and other aircraft flight services; crash, fire, and rescue services; specialized instrumentation; and miscellaneous equipment.

W88-70019 **(21) 505-66**
Ames Research Center, Moffett Field, Calif.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
G. W. Condon 415-694-5567
(505-61-00; 533-02-00)

The objective of this research is to develop a guidance and control technology base for design of safe, efficient civil and military aircraft. Research will be conducted on: (1) advanced, robust flight/propulsion control systems for superaugmented aircraft; (2) advanced guidance and display systems which fully utilize new computational capabilities evolving within the fields of artificial intelligence and decision making theory to achieve effective tactical path planning and to permit more efficient operations in the air traffic control (ATC) environment; (3) advanced analysis techniques to enhance our knowledge of atmospheric processes and other causes of aircraft accidents by analyzing data from accidents in conjunction with the National Transportation Safety Board (NTSB); (4) application of expert system, computer vision, and advanced guidance technology to enable automated rotorcraft flight in the nap-of-the-earth; and (5) application of expert system techniques to develop automation in maneuvering flight for fighter/attack aircraft. The approach will be to conduct analytic studies, evaluate concepts on flight simulators, and validate the more promising concepts in flight.

Human Factors Research and Technology

W88-70020 **(21) 505-67**
Ames Research Center, Moffett Field, Calif.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
M. G. Shafto 415-694-6170
(506-47-00; 505-61-00; 505-66-00)

The objectives are to understand the pilot's task in terms of the demands it places on human sensory, perceptual, cognitive, and communicative abilities; to apply this understanding to the development of tools for the specification, design, prototyping, and evaluation of crew/cockpit interfaces; to develop the crew/cockpit/air traffic control (ATC) interaction technology base required to improve operational safety and effectiveness; and to develop advanced crew/vehicle interfaces and operational concepts that will reduce pilot error and improve aviation safety. The approach emphasizes mathematical and computational modeling of human sensory, perceptual, cognitive, and communicative abilities. Computational models are developed and tested against quantitative human performance data collected in actual flight and in high-fidelity simulation. Validated models are used to formulate design principles for cockpit information systems and displays, such as integrated cross-sensory, multi-mode displays; to design and prototype information management and display systems which improve pilot situation awareness; and to support guidelines for cockpit automation. Validated models are also essential to the development of innovative artificial vision systems, such as those required for adverse weather and low altitude use, and to the design and implementation of computer-aided flight station design tools.

W88-70021 **(23) 505-67**
Langley Research Center, Hampton, Va.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
J. F. Creedon 804-865-4915
(505-66-00)

The overall objective of this work is to provide a research and technology data base from which solutions to human problems impeding the growth and safety of air transportation may be derived. Specific objectives include: (1) the exploration and development of concepts for integrated display and information transfer between crew and aircraft; (2) the application of artificial intelligence concepts to cockpit aids such as system status monitoring and diagnosis to facilitate safe and efficient flight operations; (3) the exploration and development of innovative control/display operational concepts involving cockpit displays of flight management information that will insure the efficient and safe use of air traffic control (ATC) system technology; (4) the development and validation of human response measurement technologies for the assessment of aerospace crew mental state; (5) the establishment of a quantitative and qualitative data base for display format/arrangement factors; and (6) the development of a technology base that will allow reliable substitution of simulators for research applications involving atmospheric environment factors.

Flight Systems Research and Technology

W88-70022 **(23) 505-68**
Langley Research Center, Hampton, Va.
FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY
R. V. Harris 804-865-3285
(533-02-00)

The objective of this RTOP is to improve the knowledge of severe storm atmospheric processes as they affect the design and safe efficient operation of aircraft and aircraft systems. Existing experimental programs will be continued to provide additional data for improving the detection and avoidance of severe storm hazards, and for the development of design and operating criteria for those hazards which cannot be avoided. Specific hazards include precipitation, wind shear, turbulence, and in-flight lightning. Advanced methods will be developed as well as vehicle concepts needed to significantly increase fighter maneuverability considering such effects of high angle of attack, separated flow conditions, vortex flaps, and thrust vectoring. Flight experiments will validate key elements.

W88-70023 **(21) 505-68**
Ames Research Center, Moffett Field, Calif.
FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY
D. H. Gatlin 805-258-3166
(533-02-00)

The overall objective is to provide for the necessary research and technology development of advanced flight systems for application to future military and civil aircraft. Research will be conducted in conjunction with high angle-of-attack flight experiments utilizing the High Alpha Research Vehicle (HARV). Near term emphasis will involve forebody flows by correlating flow visualization and surface pressures measured in flight and in

wind/water tunnels with results generated by computational fluid dynamic (CFD) analysis. The long term goal is development of flight validated predictive techniques. Research activities supporting evaluation of unconventional controls including thrust vectoring for high alpha control and maneuvering will also be conducted. In support of the U.S./U.K. ASTOVL program, contracted efforts are being conducted to evaluate supersonic single engine concepts featuring four different propulsive lift systems, followed by concept-specific technology.

W88-70024 **(22) 505-68**
Lewis Research Center, Cleveland, Ohio.
FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY
J. A. Ziemianski 216-433-3901

The overall objective of this effort is to provide for the necessary research and technology development of advanced flight systems concepts for application to future military and civil aircraft. This part of the flight systems research and technology program is focused on advancing critical technology needed to solve propulsion and icing problems associated with operation of military and civil rotorcraft and propulsion and control problems associated with operation of military high performance STOVL aircraft. The current plans for this research area are to develop analytical and experimental simulation techniques to study aircraft icing problems and to develop advanced ice protection system concepts to improve aircraft productivity, operational capability and safety, and to identify and develop propulsion technology for supersonic STOVL aircraft.

Systems Analysis

W88-70025 **(10) 505-69**
National Aeronautics and Space Administration, Washington, D.C.
SYSTEMS ANALYSIS
Cecil Rosen 202-453-2792

The objective of this effort is to provide for various activities in support of the Aeronautics Studies program. These activities include a studies contract in support of OAST aeronautics technology program requirements, assessments, planning and advocacy, as well as a continuation of support of the Radio Technical Commission for Aeronautics (RTCA), and a university advanced aeronautical design studies program.

W88-70026 **(22) 505-69**
Lewis Research Center, Cleveland, Ohio.
SYSTEMS ANALYSIS
D. C. Mikkelson 216-433-5637

The objectives of this RTOP are to perform studies of the feasibility and potential benefits of advanced subsonic, supersonic, and hypersonic propulsion concepts, to identify technology research requirements and define opportunities for capitalizing on technology advances. Studies will be performed on a wide variety of engine cycles, propulsion systems, and engine/airframe combinations in aircraft missions. Near term and long range aeropropulsion planning will be conducted to assist in the development of future NASA aeronautics programs.

W88-70027 **(21) 505-69**
Ames Research Center, Moffett Field, Calif.
SYSTEMS ANALYSIS
J. Gatlin 415-694-5070

The overall objective of this activity is to provide an information data base for advanced planning of rotorcraft research programs. This information will lead to the development of technology which will advance the state of the art of rotorcraft. Emphasis will be on promising technologies which will enable new or greatly increased capabilities of rotorcraft vehicles, innovative and/or beneficial uses of rotorcraft, and the application of emerging technologies to rotorcraft. The feasibility, potential benefits, and critical technologies of advanced, high speed rotorcraft concepts will also be assessed.

W88-70028 **(23) 505-69**
Langley Research Center, Hampton, Va.
SYSTEMS ANALYSIS
R. V. Harris 804-864-3285

The overall objective of this work is to provide long-term guidance and direction to aeronautics research and technology programs performed by NASA and the nation's aviation industry. In-house and contract multidisciplinary systems studies identify high-payoff, emerging technology needs and opportunities that can lead to significant advancements or improvements in future civil or military aircraft, creation of new markets, and economic benefits. Studies assess the feasibility and potential benefits of highly integrated configurations incorporating improvements in aerodynamics, propulsion, propulsion-airframe integration, avionics and controls, and structures and materials, Tradeoff analyses are conducted to optimize parameters and to determine the sensitivity of the configuration concepts to the required technology developments. Although research addresses vehicles for both civil and military applications across the speed range, current emphasis is focused on high-speed transportation needs and identification of the most promising future vehicle concepts based on an evaluation of the technical, economic, and timing issues.

NASP-Hypersonics Research and Technology-Aero

W88-70029 **(23) 505-80**
Langley Research Center, Hampton, Va.
NASP-HYPERSONICS RESEARCH AND TECHNOLOGY-AERO
H. Beach 804-865-3285
(506-80-00; 763-01-00)

The objective is to provide advanced technologies on a schedule consistent with the needs and requirements of the NASA/DOD National Aero-Space Plane (NASP) Program. Key research and technology efforts are required in the following areas: (1) propulsion, to provide mature high-speed propulsion technologies in areas such as scramjets, engine components, and complete engines; (2) aerodynamics (including computational fluid dynamics), to provide insight into the stability and control of vehicle concepts, the aerothermodynamic environment to which the airframe will be exposed, the complicated flow fields about the vehicle and at crucial locations such as the inlet of engines and vehicle afterbodies, and integration of the high-speed propulsion system with the airframe itself; (3) structures and materials, to provide characterization of a select group of advanced high-temperature/high-strength materials and verification of their applicability to hypersonic structures concepts, and cryogenic tankage concepts; (4) flight systems, to establish flying quality requirements and to develop guidance, navigation, and control methodologies required to meet NASP performance objectives and mission goals; (5) systems integration which provides the methodology for and the assessment of the performance levels of particular subsystems or components on overall vehicle performance.

W88-70030 **(21) 505-80**
Ames Research Center, Moffett Field, Calif.
NASP-HYPERSONICS RESEARCH AND TECHNOLOGY-AERO
James O. Arnold 415-694-5265
(506-80-00; 763-01-00)

The objective is to provide advanced technologies on a schedule consistent with the needs and requirements of the NASA/DOD National Aero-Space Plane (NASP) Program. Key research and technology efforts are required in the following areas: (1) propulsion, to provide mature high-speed propulsion technologies in areas such as scramjets, engine components, and complete engines; (2) aerodynamics (including computational fluid dynamics), to provide insight into the stability and control of vehicle concepts, the aerothermodynamic environment to which the airframe will be exposed, the complicated flow fields about the

vehicle and at crucial locations such as the inlet of engines and vehicle afterbodies, and integration of the high-speed propulsion system with the airframe itself; (3) structures and materials, to provide characterization of a select group of advanced high-temperature/high-strength materials and verification of their applicability to hypersonic structures concepts, and cryogenic tankage concepts; (4) flight systems, to establish flying quality requirements and to develop guidance, navigation, and control methodologies required to meet NASP performance objectives and mission goals; (5) systems integration which provides the methodology for and the assessment of the performance levels of particular subsystems or components on overall vehicle performance.

W88-70031 **(22) 505-80**
Lewis Research Center, Cleveland, Ohio.
NASP-HYPERSONIC RESEARCH AND TECHNOLOGY-AERO
J. A. Ziemianski 216-433-3901
(506-80-00; 763-01-00)

The objective is to provide advanced technologies on a schedule consistent with the needs and requirements of the NASA/DOD National Aero-Space Plane (NASP) Program. Key research and technology efforts are required in the following areas: (1) propulsion, to provide mature high-speed propulsion technologies in areas such as scramjets, engine components, and complete engines; (2) aerodynamics (including computational fluid dynamics), to provide insight into the stability and control of vehicle concepts, the aerothermodynamic environment to which the airframe will be exposed, the complicated flow fields about the vehicle and at crucial locations such as the inlet of engines and vehicle afterbodies, and integration of the high-speed propulsion system with the airframe itself; (3) structures and materials, to provide characterization of a select group of advanced high-temperature/high-strength materials and verification of their applicability to hypersonic structures concepts, and cryogenic tankage concepts; (4) flight systems, to establish flying quality requirements and to develop guidance, navigation, and control methodologies required to meet NASP performance objectives and mission goals; (5) systems integration which provides the methodology for and the assessment of the performance levels of particular subsystems or components on overall vehicle performance.

Interdisciplinary Technology

W88-70032 **(23) 505-90**
Langley Research Center, Hampton, Va.
INTERDISCIPLINARY TECHNOLOGY
R. W. Barnwell 804-865-2664

The objective of this work is to originate, support, promote, and maintain innovative, high-risk, long-term university-based research through research and training grants, cooperative research efforts, and joint research institutes. This is accomplished through three program elements: 0--The Fund for Independent Research (FIR), 1--The Graduate Program in Aeronautics (GPA), and 2--Joint University Institutes (JUI), which includes the Joint Institute for Advancement of Flight Sciences (JIAFS) and the Institute for Computer Applications in Science and Engineering (ICASE). The approach is as follows: The FIR funds novel, long-range, high-risk, basic research investigations in engineering and physical sciences related to aeronautics through the support of unsolicited proposals from the university community. GPA sponsors graduate training and research that is relevant and acceptable to both NASA and the university in the field of aeronautics and encourages a greater number of newly graduating U.S. citizen engineers to pursue graduate training. A significant portion of the training will be through student research conducted with faculty support at a NASA center using NASA facilities. The JUI provides a core level of funding for the promotion of an active NASA/university interchange in order to maintain cooperative, innovative, venture research at the edge of the latest technology and techniques in science, engineering, mathematics, and computers.

W88-70033 **(22) 505-90**
Lewis Research Center, Cleveland, Ohio.
INTERDISCIPLINARY TECHNOLOGY
M. J. Hartmann 216-433-2954

The overall objective is to originate, support, promote, and maintain innovative, high-risk, long-term university-based research through research and training grants, cooperative research efforts, and joint research institutes. The program is carried out primarily through grants which are selected by the Chief Scientist with the aid of the Research Advisory Board. It allows OAST to initiate fundamental studies in areas not presently included in a specific discipline program and to sponsor graduate training in aeronautics. The funds are also used to bring speakers and visiting university scientists to the Center and to hold workshops and seminars.

W88-70034 **(10) 505-90**
National Aeronautics and Space Administration, Washington, D.C.
INTERDISCIPLINARY TECHNOLOGY
Edmund L. Sanchez 202-453-2790

The objective of this effort is to provide for various support activities for the Aeronautics Research and Technology program. These activities include the Resident Research Associateship (RRA) program; the conduct of reviews, studies, and assessments of the ongoing and planned programs by the Aeronautics and Space Engineering Board (ASEB); the large-scale scientific computing program; and hypersonic training and research. The RRA program and the ASEB activities are contracted efforts, and the large-scale scientific computing program and hypersonic training and research will include university grants.

W88-70035 **(21) 505-90**
Ames Research Center, Moffett Field, Calif.
INTERDISCIPLINARY TECHNOLOGY
M. Gatlin 415-694-5113

The objective of this RTOP is to promote and maintain innovative, high-risk, university-based basic research in aeronautics through research and training grants, cooperative research efforts, and a joint research institute. The objective is accomplished through three elements within the RTOP: Fund for Independent Research; Aeronautics Graduate Research Program; and a Joint University Institute. The funds for Independent Research program supports innovative and high-risk basic research in aeronautics, usually by means of unsolicited proposals from universities. Aeronautics Graduate Research Program provides grants to support graduate training and research in aeronautics. A significant portion of the training will be through student research conducted at Ames Research Center. The Joint University Institute program provides core funding for the Ames/Stanford Joint Institute for Aeronautics and Acoustics. The Institute promotes an active NASA/Stanford interchange to maintain cooperative, innovative advanced research in the disciplines of aeronautics and acoustics.

Aeronautics Systems Technology Programs

Rotorcraft Systems Technology

W88-70036 **(23) 532-06**
Langley Research Center, Hampton, Va.
ADVANCED ROTORCRAFT TECHNOLOGY
C. P. Blankenship 804-865-2042
(505-61-00)

The objective is to develop the technology for improving rotor noise prediction methodology and noise design criteria for both military and civil rotorcraft. The approach is to acquire acoustic

data from tests of a variety of rotor and rotor system configurations and to utilize these data to develop and verify advanced noise prediction methods. This research is performed through contracts with major U.S. manufacturers of helicopters and is coordinated with in-house aeroacoustic research at Ames and Langley and with company independent research.

W88-70037 **(21) 532-06**
Ames Research Center, Moffett Field, Calif.
ADVANCED ROTORCRAFT TECHNOLOGY
C. M. McKeithan 415-694-5020

The objective of this program is to advance rotorcraft systems technology for reduced noise and for high subsonic speeds to enable advances in military and civil rotorcraft vehicles. Rotorcraft noise methodology will be improved by the acquisition of a modern airloads data base and the refinement of predictive methods. Semi-empirical design methods will be improved and analytical and computational fluid dynamics (CFD) codes will be validated. Scaling laws will be investigated by comparison of small- and large-scale model data with flight test data. Analytical capabilities, ground based facilities and flight research vehicles will be used to advance technology for high-speed rotorcraft. CFD techniques will be developed to accelerate high-speed designs. High-speed candidate concepts will be evaluated for potential development and advanced technology needs will be identified.

High-Performance Aircraft Systems Technology

W88-70038 **(21) 533-02**
Ames Research Center, Moffett Field, Calif.
HIGH-PERFORMANCE FLIGHT RESEARCH
C. R. Jarvis 805-258-3177
(505-68-00; 533-06-00)

The overall objective is to provide the flight-validated data base required for military and potential civil application of advanced technologies. Program objectives are accomplished by analysis, ground-based simulations, wind tunnel experimental research and flight research tests. Generic high angle-of-attack research will be continued with an F-18 test aircraft. Under joint NASA/USAF Advanced Fighter Technology Integration (AFTI) Program, the F-16 will commence Close Air Support/Battle Area Interdiction (CAS/BAI) technology development, and the F-111 manual and automatically-controlled mission adaptive wing flight research will be completed. The F-15 Performance Seeking Control (PSC) program will start with design and development effort to optimize the total integrated propulsion and flight control system, with subsequent flight test of key systems and modes. Development of technologies necessary to permit V/STOL aircraft to effectively operate in all mission phases and their validation will continue with the YAV-8B Harrier. The X-29 forward swept wing follow-on research phase will continue with data base development and performance assessment for the full flight envelope.

W88-70039 **(23) 533-02**
Langley Research Center, Hampton, Va.
HIGH-PERFORMANCE FLIGHT RESEARCH
R. V. Harris 804-865-3285
(505-68-00)

The objective of this work is to provide improved design methods for highly maneuverable aircraft in the areas of aerodynamic performance, stability, and control with emphasis on moderate and high angles of attack. More specifically, work will be focused on validating design methods for the vortex flap concept and validation/demonstration of high angle-of-attack aerodynamic technology applicable to fighter airplanes. The approach to be used will combine full-scale flight and wind-tunnel testing in both areas of emphasis. The LaRC F-106 will be equipped with a ground-adjustable vortex flap which was designed by computational methods and wind-tunnel tests. This flap, instrumented for pressures and loads, will be flight tested through transonic flight conditions to validate the design procedure by correlation of physical flow characteristics observed in flight versus design predictions. The focus for high angle-of-attack technology validation will be the NASA F-18 High-Alpha Research Vehicle (HARV) being instrumented and prepared for flight tests at NASA-Dryden. This program involving Ames, Dryden, and LaRC, is concentrating initially on the analysis and prediction of the separated vortex flows generated by the fuselage forebody and wing-body strakes at high angles of attack.

Advanced Propulsion Systems Technology

W88-70040 **(22) 535-03**
Lewis Research Center, Cleveland, Ohio.
ADVANCED TURBOPROP SYSTEMS
J. A. Ziemianski 216-433-3901

The objective of the Advanced Turboprop Systems effort is to develop and evaluate propeller and related drive system and aircraft technologies critical to the efficient, reliable, and acceptable operation of future advanced, high-speed, turboprop-powered aircraft. Both single- and counter- rotating propeller systems and their technologies are being evaluated. Propfan technologies will be evaluated in ground and flight testing of a large-scale single rotation propfan propulsion system. Aerodynamic, acoustic and mechanical performance will be evaluated.

W88-70041 **(23) 535-03**
Langley Research Center, Hampton, Va.
ADVANCED TURBOPROP SYSTEMS
C. P. Blankenship 804-865-2042

The objective of the program is to develop both aerodynamic and acoustic technology necessary for the design of future advanced turboprop-powered aircraft. Configurations of interest are powered by highly loaded, multi-bladed, single-rotating and counter-rotating propeller systems. Emphasis is on prediction and control of propeller aerodynamic interactions and cabin interior noise environments. The approach is to develop improved analytical and experimental methods for predicting aerodynamic flow field interactions, aircraft stability and control characteristics, propeller noise (both in the near-field and far-field), and airborne and structure-borne noise transmission through the cabin sidewall. The prediction methods are validated using wind-tunnel data and results from a joint NASA/industry flight demonstration program. The improved prediction methods and criteria will be used to guide the design of advanced turboprop propellers and aircraft configurations.

W88-70042 **(21) 535-03**
Ames Research Center, Moffett Field, Calif.
ADVANCED TURBOPROP SYSTEMS
D. P. McKeithan 415-694-6618

The work covered by this RTOP is the development of the technology to demonstrate the feasibility of advanced turboprop transport aircraft capable of cruise speeds up to 0.8 Mach number and altitudes above 35,000 feet. Theoretical and experimental studies will be conducted to define the aerodynamic technology required to integrate advanced turboprop propulsion systems with supercritical wings and fuselages. Detailed flow interactions among the propeller slipstream, nacelle, pylon and wing surface or fuselage will be examined and methods to optimize the installation identified. Theoretical analyses will include linear and non-linear methods capable of handling the transonic slipstream-nacelle-wing or nacelle-pylon-fuselage interactions. Experimentally, the flow interactions will be measured with powered full- or semi-span wind tunnel models and flight vehicles that provide accurate simulation of the actual flow conditions. A series of full-span, powered models will be built to measure stability and control characteristics and to

compare installed thrust efficiencies of single- and counter-rotation propfan designs.

W88-70043 **(22) 535-05**
Lewis Research Center, Cleveland, Ohio.
GENERAL AVIATION/COMMUTER ENGINE TECHNOLOGY
J. A. Ziemianski 216-433-2901

The objective of this effort is to provide the advanced technology base needed to insure the technical advantage of U.S. manufacturers in the future small turbine engine marketplace. The approach is to evolve, evaluate, and verify critical advanced technology applicable to gas turbine engines of 250 to 5,000 shp suitable for general aviation, commuter, rotorcraft, and cruise missile applications. Analytical and experimental studies will emphasize revolutionary powerplant improvements in the 250 to 1,500+ shp range. Program subelements are: (1) system studies; (2) discipline research and technology; and (3) component research and technology. This overall approach will provide industry with the capability to design and build small engines with performance, reliability, maintainability, and durability approaching that of large engines. The technology evolved, while primarily applicable to small engines is also applicable to higher thrust engines. This is especially true for very high pressure ratio engines (to 100 atm) which will approximate the smaller engines in geometrical size.

W88-70044 **(22) 535-07**
Lewis Research Center, Cleveland, Ohio.
ADVANCED HIGH-TEMPERATURE ENGINE MATERIALS TECHNOLOGY
R. L. Davies 216-433-5015
(505-66-00)

The major objective of this RTOP is to develop the technology for revolutionary advances in materials to enable the development of 21st century high-performance propulsion systems having greatly increased thrust/weight ratio, improved reliability, and extended life. To accomplish this objective very high-temperature, lightweight material systems and the associated processing technologies will be developed. This includes the development of advanced metals, fibers, and metal matrix composites, advanced ceramic fibers and ceramic matrix composites. Advanced analysis design methods, and life prediction methodologies will also be developed to support the use of these materials in advanced turbine engines. Generic propulsion system structural concepts will be used to evaluate the advanced materials and determine the validity of structural analysis methodologies developed under the program.

Numerical Aerodynamic Simulation

W88-70045 **(21) 536-01**
Ames Research Center, Moffett Field, Calif.
NUMERICAL AERODYNAMIC SIMULATION (NAS)
F. R. Bailey 415-694-4500
(536-02-00)

The objectives of the NAS program are threefold: to act as the pathfinder in advanced, large-scale computer system capability through systematic incorporation of state-of-the-art improvements in computer hardware and software technologies; to provide a National computational capability to NASA, DOD, other Government agencies, universities and industry in order to ensure continuing U.S. leadership in computational fluid dynamics and related disciplines; and to provide a powerful research tool for the NASA Office of Aeronautics and Space Technology. The NAS Program is composed of three elements--the computer processing system (the NAS Processing System Network or NPSN), the facility to house the associated machines and people, and the operation of the NPSN. This RTOP covers the overall management of the Program, the facility and development of the processing system. It does not cover the operations elements. The NPSN technical approach is one of phased and evolutionary development which will incorporate the latest advancements in scientific supercomputers, graphics devices, storage media and other computer system technologies.

W88-70046 **(21) 536-02**
Ames Research Center, Moffett Field, Calif.
NUMERICAL AERODYNAMIC SIMULATION (NAS) OPERATIONS AND MANAGEMENT
F. R. Bailey 415-694-4500
(536-01-00)

The objectives of the NAS program are threefold: to act as the pathfinder in advanced, large-scale computer system capability through systematic incorporation of state-of-the-art improvements in computer hardware and software technologies; to provide a National computational capability to NASA, DOD, other Government agencies, universities and industry in order to ensure continuing U.S. leadership in computational fluid dynamics and related disciplines; and to provide a powerful research tool for the NASA Office of Aeronautics and Space Technology. The NAS Program is composed of three elements--the computer processing system (the NAS Processing System Network or NPSN), the facility to house the associated machines and people, and the operation of the NPSN. This RTOP covers the operations elements of the NAS Program. It does not cover the overall management of the Program, the facility and development of the processing system.

Space Research and Technology Base

Aerothermodynamics Research and Technology

W88-70047 **(23) 506-40**
Langley Research Center, Hampton, Va.
AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY
R. R. Blankenship 804-865-2893
(506-48-00; 506-49-00)

This research is to improve the fundamental understanding of aerodynamic and aerothermodynamic flow phenomena over ascent and entry vehicles and to develop the predictive capability to permit performance optimization of advanced aerospace vehicles. Emphasis is on providing flow-field computational regimes; providing analytical and turbulence chemistry models; utilizing Shuttle wind-tunnel, flight, and analytical prediction data to validate techniques for the design of future vehicles; providing the design and performance parameters on advanced vehicles to identify and analyze high payoff technologies; scoping heating problems on advanced concepts and developing prediction techniques; providing the experimental and analytical data base to improve understanding of the interaction of high temperature and Mach number on current and advanced vehicles; and improving wind-tunnel technology, test techniques, and instrumentation for fundamental research. Results will enhance the capabilities, reliability, versatility, and efficiency of future aerospace vehicles. Analytical, computational, and experimental techniques are included in the fundamental research conducted in house, by university grants, and under contract to industry. The experimental portion of the program emphasizes the unique Langley Hypersonic Facilities Complex and the 8-Foot High Temperature Tunnel.

W88-70048 **(21) 506-40**
Ames Research Center, Moffett Field, Calif.
AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY
J. O. Arnold 415-694-5265
(505-60-00; 506-43-00; 763-01-00)

The objective is to advance the fundamental understanding of aerodynamic flow phenomena in hypersonic flight regimes and to develop the predictive capability to permit performance optimization of advanced aerospace vehicles. Advanced computation methods and computer codes will be developed and validated for numerically

simulating vehicle flow fields. The results will then be used to predict thermal loads to, and aerodynamic performance of the vehicle. The codes will yield solutions for the full Navier-Stokes equations for a chemically reacting and radiating gas. The real gas properties-reaction rate constants, radiative transition probabilities and high-temperature transport properties will be determined from computational chemistry methods. Such developments depend on results of both numerical simulations and experiments for improving and/or validating these complex codes. In addition, engineering models are being developed that will give reasonable approximations of the benchmark results. Experimental research will be performed leading to nonintrusive instrumentation for use in hypersonic wind tunnels, to measure local density, temperature, pressure, and their fluctuations anywhere in the flow field having optical access. This extended measurement capability will be developed for application to code-validation and flow-modeling experiments.

Space Energy Conversion Research and Technology

W88-70049 **(23) 506-41**
Langley Research Center, Hampton, Va.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
R. R. Nunamaker 804-865-2893

This program is part of the power management effort. It contains two research areas: (1) laser space power transmission, and (2) advanced concepts. The goal of the laser area is to assess the scientific and technical feasibility of spacecraft-to-spacecraft power transmission for propulsion and for electric power distribution. Direct and indirect solar-pumped lasers are conceived, tested, and modeled. Near-term objectives are to define efficient solar-pumped lasers and to establish scaling laws for estimating high average power operation. In conjunction with laser energy generation, laser-to-electric conversion is a major aspect of laser transmission for electric power distribution. A potentially high- efficiency concept being studied is laser photovoltaic conversion. To assess the advantages of space power transmission and to guide the laser and converter research, limited trade-off studies are performed. Advanced concept research is primarily focused on plasma switch experiments. The plasma switch operates in an inverse-pinch mode with the objective of high power, long life operation. The device can either close or open a circuit and research is a combination of experimentation and modeling. Potential applications for this type of switch include pulsed power requirements for advanced electric propulsion in space, for terrestrial and defense missions, and for electromagnetic launching of large payloads.

W88-70050 **(55) 506-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
Kenneth L. Atkins 818-354-6293

The objective is to develop and demonstrate advanced technologies in the areas of power switching and control, chemical energy conversion, photovoltaic energy conversion, and thermal energy conversion for applications/spacecraft power systems up to 25 kW. The overarching theme of the program is high density power technology to keep the volume-percentage of the power subsystem within the bounds of 20 percent of total space system volume. Current state of the art is about 1 W/cu in. The eventual objective is 10 W/cu in. by the year 2000, a factor of 10 improvement. Without such progress, typical power subsystems could require over 60 percent of total system volume. To enable this achievement will require steady progress in power switching and control functions from discrete to hybrid and monolithic technologies; continuing the drive toward long-lived (10 year), high-energy-density (200 to 400 W-hr/kg) primary batteries, and toward 10 year, 100 W-hr/kg rechargeables; developing and demonstrating photovoltaic array technology at 300 W/kg and/or 300 W/sq m (for near sun and selected electric propulsion missions); and thermal conversion technology thrusts along both solid-state and liquid-metal or alkali metal thermoelectric converter (AMTEC) avenues to reach conversion efficiencies in the 15 to 20 percent range without moving parts. Approaches will include industrial and university co-op tasks to achieve prototypes and demonstration elements, with solid analytical support.

W88-70051 **(72) 506-41**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
Walter W. Guy 713-483-4931

The objectives of this effort are to develop the physico-chemical regenerative life support and closed loop life support systems technologies which will enable an orderly growth in both system size and capability for future manned missions in space, such as Lunar and Mars missions. Development of systems and subsystems analytical models also are to be emphasized. The tasks included for regenerative and closed loop life support are directed at improving process efficiencies, reducing expendables and attaining a higher degree of system closure. Particular emphasis will be placed on the technology development and analytical modeling of advanced processes to accomplish the life support functions of air revitalization, water recovery, and waste management. The integration of these regenerative technologies with biological subsystems to enable a higher degree of system closure will also be addressed.

W88-70052 **(22) 506-41**
Lewis Research Center, Cleveland, Ohio.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
H. W. Brandhorst 216-433-6149

The objective of this work is to provide a research and technology development base leading to a spectrum of advanced space power systems and subsystems. Areas include photovoltaics, electrochemical energy storage, fault tolerant power management and distribution components and subsystems, spacecraft environmental interactions, integrated spacecraft bus technology, thermal and solar dynamic systems, advanced radiator concepts, two phase flow in zero-G, and supporting technology for the SP-100 nuclear power system focusing on free-piston Stirling engines. Major thrusts are to improve performance, reliability and tolerance to the plasma and radiation environment while reducing cost and mass, where appropriate, for systems operating in the LEO, GEO and planetary environments. The research generally aims at providing the technological base for emerging ten-to-hundred kilowatt and ultimately to megawatt level power system needs, while also recognizing and addressing agency and other needs up to the ten kilowatt level.

W88-70053 **(10) 506-41**
National Aeronautics and Space Administration, Washington, D.C.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
Gregory M. Reck 202-453-2847

The objective of this RTOP is to provide support to the Headquarters operation of the OAST Space Energy Conversion Program. This will include operation of the multi-agency-supported power information center of the Interagency Advanced Power Group.

Propulsion Research and Technology

W88-70054 **(62) 506-42**
Marshall Space Flight Center, Huntsville, Ala.
PROPULSION RESEARCH AND TECHNOLOGY
R. J. Richmond 205-544-6645

The purpose of this RTOP is to extend and further develop the propulsion technology base in support of advanced, high performance, reusable, space based orbital transfer vehicle. The propulsion technology activities described herein for orbit-to-orbit application include investigation of high area ratio nozzle concepts, extendible nozzle joints, lightweight nozzle materials and construction techniques, and further development and refinement of performance prediction models for high area ratio nozzles.

W88-70055 **(22) 506-42**
Lewis Research Center, Cleveland, Ohio.
PROPULSION RESEARCH AND TECHNOLOGY
D. A. Petrash 216-433-2439

The objective is to provide the technology base for all types of primary and auxiliary space propulsion systems. Included are future reusable hydrogen/oxygen and high-density/oxygen Earth-to-orbit propulsion systems; advanced space-based orbit-to-orbit propulsion systems; long-life high performance low thrust propulsion systems; high specific impulse spacecraft primary propulsion systems; and advanced propulsion concepts.

W88-70056 **(10) 506-42**
National Aeronautics and Space Administration, Washington, D.C.
PROPULSION RESEARCH AND TECHNOLOGY
Gregory M. Reck 202-453-2847

The primary objective of this activity is to maintain a continuous up-to-date information gathering capability on the nation's total chemical propulsion technology efforts as an aid in planning and implementing the NASA program. In addition, joint interagency tasks are undertaken when appropriate, such as publishing handbooks, manuals or computer models, that will be beneficial to the propulsion community as well as other potential users. The approach is to share support of the Chemical Propulsion Information Agency (CPIA), which supplies information gathering and dissemination services, with DOD agencies through the Joint Army, Navy, NASA, Air Force (JANNAF) Interagency Propulsion Committee. For special interagency tasks, funding is transferred to the agency designated as responsible for the procurement action and contract monitoring.

W88-70057 **(55) 506-42**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROPULSION RESEARCH AND TECHNOLOGY
J. F. Stocky 818-354-3575

The objective is to study advanced propulsion system concepts in order to identify critical technology development requirements, and also to develop and demonstrate feasibility for the most promising concepts. Studies and laboratory experiments have initially shown the feasibility of ion and Magneto Plasma Dynamic (MPD) propulsion concepts. Efforts in the coming year will focus on both fundamental research to identify and model the basic physics of operation, and on development of critical components such as high-current cathodes, new fuels, and new steady-state operating MPD thrusters. These developments will lead to a technology readiness for mission application in the 1990s. For the more ambitious missions of the 21st century, studies will be carried out to identify propulsion concepts which offer substantial performance increases. Study candidates include nuclear fission or fusion, beamed microwave or laser energy, solar sails, and anti- proton annihilation. These studies will examine feasibility issues, define critical technology development requirements, and proof-of-concept experiments that are required both to evaluate these advanced concepts, and to guide future technology development programs.

Materials and Structures Research and Technology

W88-70058 **(23) 506-43**
Langley Research Center, Hampton, Va.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
C. P. Blankenship 804-865-2042

The research includes executing analytical and experimental programs in structures and materials with emphasis on: (1) thermal structures and aerothermal effects; (2) structural concepts; (3) polymeric materials, metallic materials, and composite materials; and (4) interdisciplinary analysis and optimization. The objective is to develop structures and materials technologies that will enhance the performance, efficiency, and reliability of spacecraft and space transportation systems. Analytical, computational, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry.

W88-70059 **(55) 506-43**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
Charles E. Lifer 818-354-6580

The objective is to develop advanced materials and structures technology for use in future space systems. Analytical and experimental research will be conducted to investigate new methods for predicting the chemical, physical and mechanical properties and reactions of spacecraft materials such as polymers, composite matrices, alloys and heat shields. Greater understanding of the correlation between molecular parameters and observed mechanical properties will lead to a capability for producing very specific mechanical characteristics by utilizing innovative molecular designs. Analytic capability which includes design optimization, fabrication, testing and performance prediction of advanced structural composite materials such as carbon-carbon composites will also be developed. In the area of space environmental effects, beams of energetic oxygen atoms, charged particles, and short wavelength UV light, will be used along with spectroscopic and analytical techniques, to characterize the degradation processes of polymers in a simulated space environment. These experiments will determine the long term effects of the space environment. Research on flexible structure dynamics will develop new methods, and improve existing methods for the analysis and synthesis of large complex structural systems. Ground testing to validate existing models of predicting dynamic behavior of large flexible structures will also be carried out.

W88-70060 **(21) 506-43**
Ames Research Center, Moffett Field, Calif.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
J. O. Arnold 415-694-5265
(763-01-00; 506-40-00; 506-48-00)

The objective is to provide advanced materials technology for the development of future space systems with significant improvements in performance, durability and economy. Emphasis is given to computational materials science and thermal protection materials development. In computational chemistry, the physical and chemical properties of molecules, small atomic clusters and gas-surface interactions are calculated from first principles. These and extrapolations to larger systems are being studied to compare with experiment and to obtain surface and bulk properties. These results are used to study chemisorption, catalysis, corrosion and the physical properties of polymers. Ames' unique arc-plasma test facilities, ceramic materials laboratory, and analytical and computational capabilities are used to develop materials and optimized systems for advanced space transportation vehicles, enhanced Space Shuttle vehicles, aeroassisted orbital transfer vehicles (AOTV), transatmospheric vehicles (TAV), planetary and solar probes, and safe earth reentry of radioactive power sources. Candidate thermal protection system (TPS) concepts and materials are selected and subjected to systematic analysis and testing to qualify for defined end use.

W88-70061 **(22) 506-43**
Lewis Research Center, Cleveland, Ohio.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
S. J. Grisaffe 216-433-3190

The objectives of this RTOP are to develop greater understanding of materials with aerospace propulsion and power potential and to develop guidelines for improving their physical/mechanical properties and reliability. Fundamental studies are aimed at investigating mechanical and other factors that limit material reliability, performance, and useful life. Fundamental studies are also aimed at identifying scientific concepts that might be applied to substantially improve aerospace materials. The research includes: (1) material properties/performance enhancement via innovative application of nondestructive evaluation concepts/models for characterization of microstructure and mechanical properties; (2) understanding the basics of friction, wear, adhesion, thin film liquid lubrication, and the chemistry and morphology of solid lubricants; (3) work to develop ceramic matrix composites for aerospace applications; and (4) development of materials for heat storage and space power applications. The analytical and experimental results of this RTOP will have far reaching practical applications for a wide range of aerospace materials, structures, and components.

W88-70062 **(72) 506-43**
Lyndon B. Johnson Space Center, Houston, Tex.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
J. T. Nunamaker 713-483-8923

The objectives are to: (1) develop and calibrate an atomic oxygen (AO) beam source and conduct ground-based simulation of AO effects on materials, coatings, and lightweight, flexible structures for potential use on Space Station; and (2) examine the effects of hypervelocity impacts from meteoroids and orbital debris on composites. An AO facility at Los Alamos National Laboratory will be used to conduct studies within a simulated orbital environment and investigate the effects of extended exposure (10 to the 22nd power to 10 to the 23rd power atoms/sq cm) on a limited number of Space Station materials, with the results of these investigations to be verified later during the Evaluation of Oxygen Interaction with Materials 3 (EOIM-3) oxygen effects experiment, which will enable accurate reaction rate measurements to be obtained for a large number of Space Station materials. The examination of the hypervelocity impact resistance of composites will be carried out in the Hypervelocity Impact Research Laboratory (HIRL) using small projectiles of varying densities, with data to be incorporated into refining the present mathematical model.

W88-70063 **(51) 506-43**
Goddard Space Flight Center, Greenbelt, Md.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
Roy Roberts 301-286-3478

The overall objective of this plan is to develop and verify contamination models leading to improved prediction capability, new materials and protective methods. The current plans for this research are to develop and fly instrumentation to characterize induced on-orbit environments; develop ground-based facilities for material characterization; develop a data base; improve, develop and verify models; advance material development; and develop protective and collective devices development. Some aspects of these efforts will be accomplished with joint programs between NASA and the European Space Agency by combining capabilities and technical strengths of both agencies.

W88-70064 **(10) 506-43**
National Aeronautics and Space Administration, Washington, D.C.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
Samuel L. Venneri 202-453-2760

The objective of this RTOP is to develop a wide range of analytical tools and experimental techniques for use in the design, development, and analysis of the structures and structural dynamics of complex spacecraft and space structures. The program will be structured to foster innovative engineering solutions and design concepts for such vehicles. A number of key structural integrity issues will be addressed in order to develop the understanding and tools needed for the next generation of space structural design concepts.

Space Data and Communications Research and Technology

W88-70065 **(51) 506-44**
Goddard Space Flight Center, Greenbelt, Md.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
M. F. Dalton 301-286-8942
(650-75-01)

The objective of the research in communications is to develop and demonstrate the advanced transmitter and receiver technology required for high-performance space-borne laser communication systems. Such systems are required for future high-speed intersatellite communications. The emphasis of the program is on the development of semiconductor laser transmitter modules which are suitable for use in high data rate communication systems. In a parallel effort, research will be carried out in advanced receiver technology. Work will address optimizing receivers with existing detector technology and developing new very-low detectors. The objective of the research in software engineering is to develop a software management environment consisting of an integrated set of tools, software measures, and a knowledge base of software management expertise to improve the management and development of large, complex software systems.

W88-70066 **(23) 506-44**
Langley Research Center, Hampton, Va.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
J. F. Creedon 804-865-4915
(506-45-00)

The objective is to research new component and system concepts in Space Data and Communications Systems. This research and concept development will result in planning, development, and delivery of technology elements through R and D studies, system models to establish feasibility, proof of concept, or engineering validation hardware and software builds as appropriate to demonstrate technology readiness in support of planned missions. The mission set includes Advanced Transportation Vehicles, Space Station, Earth Observing Systems, Lunar Colonies, and Mars Rovers in the area of embeddable data systems and communications. The approach is to use mission identified system level needs, together with new device and systems level technologies in high-speed space qualifiable processors, large capacity electro-optical memories with no moving mechanical parts, light based interconnect structures to encompass both optical channel switched and bussed interconnection of subsystem elements, antenna components and analyses, optical communications subsystems components, each to give enabling and enhanced system level performance. Particular elements will be developed through proof of concept, and this technology will be delivered to mission projects by appropriate jointly funded developmental proof of performance test vehicles. Individual tasks included are Semiconductor Lasers, Multibeam Feeds for Spaceborne Antennas, and Millimeter Wave Technology.

W88-70067 **(72) 506-44**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
S. A. Gorman 713-483-5272

This proposal continues support of the NASA sponsored Software Engineering Research Center at the High Technologies Laboratory of the University of Houston at Clear Lake (UHCL). The center will provide a means of focusing NASA research into software engineering issues and will also provide a formal liaison with other similar centers of research such as the Department of Defense Software Engineering Institute (SEI) at Carnegie Mellon University. Areas of research will include: new techniques in software lifecycle management; productivity tools for software development and maintenance; development and maintenance of distributed information systems, especially non-stop embedded systems; NASA software engineering training requirements; advancements in operating systems and network operating systems; advancements in computer networks; software fault tolerance; multilevel computer security; use of the ADA language and associated environments on NASA projects; application of expert systems and artificial intelligence techniques to lifecycle management; and others as directed by NASA.

W88-70068 **(21) 506-44**
Ames Research Center, Moffett Field, Calif.
SPACE DATA COMMUNICATIONS RESEARCH AND TECHNOLOGY
M. C. Arnold 415-694-5188
(505-65-00)

The objective is to develop systems architectures for spaceborne applications which significantly enhance onboard computational capability and improve reliability. Of particular interest is the development of novel memory and sensory encoding architectures which permit learning and image recognition. The approach involves collaboration between the Computer Systems Laboratory (CSL) at Stanford University and Ames' Research Institute for Advanced Computer Science (RIACS). This collaboration will bring together the hardware design and fabrication capability of CSL, the architecture design and systems software development capability of RIACS, and the space requirements which are well known by the space scientists within NASA. Currently a prototype of a Sparse Distributed Memory architecture is being constructed so that its applicability to several space science applications can be determined.

W88-70069 **(22) 506-44**
Lewis Research Center, Cleveland, Ohio.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
Denis J. Connolly 216-433-3503
(584-00-00)

The overall objective of this RTOP is to provide through research, design and experimental tests, the components, subsystems and enabling technology required to support NASA satellite communications systems. To achieve this objective, advanced research and development programs will be conducted to identify, produce and demonstrate critical components, techniques and subsystems required for complete communications systems. Principal emphasis will be directed toward spacecraft microwave electron beam amplifiers with increased power output, linearity, efficiency, high frequency capability and long life; multi-frequency, multi-beam antennas providing increased frequency reuse at higher frequencies; and solid state materials and component technology for high frequency spacecraft applications, such as switching, power amplification and beam forming.

W88-70070 **(55) 506-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
Arthur J. Murphy 818-354-6457
(506-45-00; 584-02-00)

Neural network research, which will significantly expand our ability to do intelligent information processing, will pursue the development of materials and device configurations leading to erasable microswitches (synapses), and the investigation of neural network applications for NASA missions. The objective for the software engineering is to conduct research into the development of tools to support reuse of knowledge in software development for space data systems. The technical approach will involve the development of a knowledge base describing the objectives and components of space data systems, and the major design decisions involved in their development. The requirements acquisition tools will support the rapid development of conceptual models of space data systems from these components. The objective and approach of the communications activity are to develop technology to support the development of Ka-band transmitters for advanced deep space communications systems, to develop optical and microwave deep space and near-earth technologies, and to maintain a national preeminence in space communications. The plan is to develop a high power and power efficient laser transmitter and modulator for environmental tests of critical design issues. An integrated optical communication test bench for the evaluation and demonstration will be assembled and tested.

Information Sciences Research and Technology

W88-70071 **(23) 506-45**
Langley Research Center, Hampton, Va.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
W. D. Mace 804-865-3745

The objective of this program is to develop solid-state IR and far-IR detectors for active remote sensors supporting high-flying aircraft and space-based earth science investigations in atmospheric dynamics and chemistry. This research and technology program has been structured to approach these challenges in the areas of laser materials research, laser transmitter design and development, lifetime and efficiency improvement as well as detector research and development. This work addresses the improvement of IR and far-IR sensors and sensor systems through theoretical studies and single crystal materials development.

W88-70072 **(55) 506-45**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
Arthur J. Murphy 818-354-6457
(584-00-00)

The objective of this work is to develop the technology which forms the basis of the sensing, use, and management of space-derived information, and to expand the applications of advanced information sciences and photonics technology in space. A complementary set of objectives is to provide an agency-wide foundation in fundamental aerospace computer science, to facilitate the infusion of state-of-the-art computing technology into aerospace applications, and finally to advance photonic optical processing technology to augment NASA mission capabilities. The approach in the passive and active remote sensing element of this work is to conduct advanced materials research and device development activities to enhance our understanding of semiconductors in all areas of the electromagnetic spectrum. This specifically includes basic Materials Support applied to artificial structure materials (ASMs) in the III-V system and solid state laser device development supporting active remote sensing and solid state laser pumping. The approach in computer science and photonics is to participate in the NASA Computer Science and Photonics Working Group and to develop a 5-year plan, to apply the expert system spectrum in image processing, and to develop parameters for the generic model by identifying common space applications.

W88-70073 **(21) 506-45**
Ames Research Center, Moffett Field, Calif.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
C. R. Arnold 415-694-6549
(584-01-11; 506-49-21; 584-01-41)

One objective is to develop advanced infrared detector array

technology for future astronomical applications. The array technology is applicable to low- and moderate-background astronomical applications throughout the infrared (IR) spectrum (2 to 200 micrometers) and will directly benefit programs such as the Space Infrared Telescope Facility (SIRTF) and the Large Deployable Reflector (LDR). These activities blend analysis with component development, and include extensive in-house characterization and selected technology demonstrations. A second objective is to develop technologies in artificial intelligence and information sciences leading to an image-based advanced machine intelligent system for spaceborne applications. Emphasis is in the areas of spaceborne optical processing architectures, information understanding, knowledge acquisition and learning. A cooperative Ames-academia-industry team consisting of leading-class researchers has been established to conduct the required research.

W88-70074 **(51) 506-45**
Goddard Space Flight Center, Greenbelt, Md.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
H. P. Dalton 301-286-6185

This effort includes fundamental and applied research in computer sciences and sensor technology for remote scientific observations. The sensor technology program aims toward dramatic advances in space and earth sciences observational capabilities. Monolithic arrays of X-ray spectrometer detectors are being developed, with high spectral resolution at energies below 30 KeV. Diode laser local oscillators and photomixers are being developed as components of an infrared heterodyne spectrometer receiver suitable for astronomy and planetary flight missions. Tunable lasers with novel resonator configurations and external wavelength shifters are being developed to provide efficient long-life sources for spaceborne atmospheric lidar missions. The objectives of the research in computer science are: (1) to study, design, and implement systems to handle very large multi-source databases managed at distributed locations; (2) to experiment with and apply expert system front ends to aid in extracting relationships from correlative information in complex scientific databases; (3) to develop concurrent processing algorithms critical to space research and data analysis; and (4) to establish a consortium of university, industry, and government scientists as a center of excellence in space data and information sciences to perform research in NASA's long term space and earth science computational problems.

W88-70075 **(10) 506-45**
National Aeronautics and Space Administration, Washington, D.C.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
Lee B. Holcomb 202-453-2747
(505-37-10)

The objective of the aerospace computer science university research is to develop a university-based center for aerospace computing technology, focusing on concurrent processing, highly reliable computing, and scientific and engineering information management. It also fosters cooperative, coordinated research coupling computer science with aeronautics, astronautics, and space sciences. The objective of the Advisory Group on Electronic Devices (AGED) program is to provide effective coordination of NASA-sponsored research and development efforts on electronic devices and systems with similar work supported by DOD and other government agencies. Through associate membership on AGED and its constituent working groups, NASA program managers receive expert advice on the feasibility, currency and soundness of planned research and development procurement activities, long ranging research and development requirements, complementary work in other government agencies, and forecasts of new technical developments.

Controls and Guidance Research and Technology

W88-70076 **(62) 506-46**
Marshall Space Flight Center, Huntsville, Ala.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
H. B. Waites 205-544-1441

The overall objective of this research is to define, develop, and demonstrate advanced control concepts for the stabilization and control of future spacecraft, payload pointing systems, and advanced transportation vehicles. The work is focused in two primary areas: the stabilization and control of large flexible structures in space and advanced control techniques for the next generation of space transportation vehicles. In the first area, the effort will be a continuation of the ongoing analytical and experimental investigation of flexible body control techniques. Here, the principal end product will be new control techniques for pointing, slewing, and actively rigidizing large systems in space. The second area represents an expansion in scope to address improvements in vehicle control design practice which will result in reduced transportation system operational cost and at the same time enhance system reliability and utility.

W88-70077 **(23) 506-46**
Langley Research Center, Hampton, Va.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
J. F. Creedon 804-864-4915
(585-01-00)

The purpose of this RTOP is to provide fundamental and applied guidance, navigation, and control (GN and C) research and technology for advanced spacecraft, space platforms, and transportation vehicles. Major activities are to advance the state of the art in control of large flexible space structures through the development of advanced modern control theories and attendant analytical and design tools. Advanced, autonomous GN and C concepts are under study for advanced space transportation system elements and orbital return and planetary entry vehicles using aerodynamic deceleration. Advanced control modeling techniques and on-line identification will be utilized with dynamic models of such spacecraft as a manned space station, Shuttle-attached experiments, large diameter antennae, advanced space transportation system concepts, and reentry vehicles. Resulting GN and C system implementations will be thoroughly evaluated via high-fidelity computer simulations, and where applicable in conjunction with complementary ground and flight test programs being conducted under other programs.

W88-70078 **(72) 506-46**
Lyndon B. Johnson Space Center, Houston, Tex.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
K. J. Cox 713-483-8224
(505-66-00)

The objective is to develop and assess guidance, navigation, and control concepts, techniques, and design methodologies to provide needed capabilities for the full and cost-effective utilization of current and future space systems. Methodologies for the cost-effective development and implementation of control capabilities will also be evaluated. Technology needs will be addressed across interacting space fleet elements, including the shuttle, Orbital Maneuvering Vehicle (OMV), Orbital Transfer Vehicle (OTV), Manned Maneuvering Unit (MMU), free-flyers, and space station. Studies will be directed toward technology developments which have the broadest application to these fleet elements and which integrate the requirements and constraints associated with the interactions of these elements. Emphasis will be placed on the development of control technologies supporting integrated orbital operations and services. This activity will also involve the development and demonstration of a system architecture and associated design and evaluation methodologies which will effectively serve the need for advanced information processing across a broad spectrum of future NASA missions. The approach used will be to conduct studies, analyses, and trade-off studies to define hardware and software requirements.

W88-70079 **(21) 506-46**
Ames Research Center, Moffett Field, Calif.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
D. A. Arnold 805-258-3136
(505-66-00)

The objective is to develop methods and identify opportunities in which advanced controls and guidance concepts can be utilized for hypersonic vehicles to obtain substantial performance gains. This will include use of powerful onboard processing as well as remote computation in support of flight research and envelope expansion. The approach is to perform studies, simulations, and flight research utilizing candidate advanced systems. Advanced simulations utilizing the most modern visual and motion based simulators, such as the Vertical Motion Simulator (VMS), would be conducted. Use of remote computation in support of flight research will allow validation of the advanced concepts in the real flight environment.

W88-70080 **(55) 506-46**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
John B. Dahlgren 818-354-4065

The objective of this research is to develop and evaluate advanced control and guidance concepts, designs, algorithms, and components required for the autonomous control, pointing, guidance, and stabilization of future space systems including large space antennas and platforms, the evolutionary space station, orbit transfer vehicles, and advanced earth orbiters and planetary spacecraft. The approach is to: (1) develop and validate system identification techniques and software for automated monitoring of system performance, adaptive control designs for autonomous compensation of dynamic uncertainties and/or configuration change, and unified controls/structure modeling and design methodology for improved robustness; (2) develop two advanced guidance and control components: FORS, a long-life all-solid-state integrated optics fiber gyro, and SHAPES, a 3-dimensional position optical sensor for static and dynamic figure measurement and dynamic identification of flexible spacecraft and large antennas; (3) develop and evaluate micron accuracy measurement concepts and technologies suitable for use in the control of future large optical interferometers and segmented systems; (4) develop and validate technologies for an actively controlled softmount interface for precision payload pointing; and (5) develop and validate controls and guidance concepts for future aeromaneuvering spacecraft.

Human Factors Research and Technology

W88-70081 **(21) 506-47**
Ames Research Center, Moffett Field, Calif.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
M. G. Shafto 415-694-6170
(505-67-00; 906-84-00; 199-22-62)

Relative to previous space missions, the International Space Station and other manned missions now being planned will involve more autonomous operation to reduce the costs of ground support. They will also incorporate increased automated on-board systems to increase productivity. The Space Station will house and support a more heterogeneous crew, and will use extravehicular activity (EVA) on a routine operational basis. To ensure high levels of safety and productivity for future space missions, research will be conducted in two areas: crew-station design and EVA. The objectives are to develop a technology base for intelligent operator interfaces, especially interfaces to autonomous subsystems, and to develop a new generation of high-performance space suits, gloves, and end effectors that meet the requirements of advanced space missions. Research will be conducted in laboratories and simulators. Demonstrations of interface technology will be conducted in engineering testbeds at Ames and other NASA Centers. Advanced suits, gloves, and EVA hardware will be developed, prototyped, and tested to provide proofs of concept.

W88-70082 **(72) 506-47**
Lyndon B. Johnson Space Center, Houston, Tex.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
B. J. Woolford 713-483-3701

The objectives are to develop technologies for increasing the productivity, efficiency, effectiveness, and safety of man-systems interactions in space flight, and to advance the fundamental understanding of human interaction with increasingly complex and automated systems. The major tasks include development of guidelines for man-machine interfaces, development of models and developing sophisticated means for data collection, developing a technology base of human interfaces with artificial intelligence, and development of new technology crew interface and performance aids for the extravehicular astronaut. To complement the basic research performed, the approach emphasizes the transfer of technologies developed from the research activities to a state that permits applications to ongoing programs. The tasks for Crew Station Human Factors cover a range of activities, from examining display formats and procedures to collecting and analyzing the operational experience of humans in space in establishing a NASA man-systems database. The emphasis is on experimentation, with analysis of the results leading to theories and models that can be generally applied. Extravehicular activity (EVA) tasks emphasize both the physical and cognitive aspects of space operations. Systems for more precise anthropometric mapping and for suit performance evaluations are being developed. A helmet mounted display for the EVA suit is being evaluated with different display technologies and formats.

W88-70083 **(55) 506-47**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
A. K. Dahlgren 818-354-4568
(549-02-00; 906-75-00)

The general objective is to develop the technology base for man-equivalent capabilities in remote material handling, construction, servicing and other manipulative operations which require mechanical dexterity together with the fusion of a variety of sensor information conveyed to the operator during task performance. The basic man-equivalent capability for manipulative dexterity resides in the dexterous capabilities of end effectors attached to remote manipulators. The technical approach to providing man-equivalent capabilities for remote manipulation with rich information feedback to the operator will utilize the design, development and evaluation of a dexterous and anthropomorphic arm-hand system in master-slave hybrid position and force feedback mode of control. The development will start with a single master-slave arm-hand system, followed by the development of a dual master-slave arm-hand system configuration. The system evaluation and demonstration will start with no time delay in the control communication, followed with short (less than 1 sec) time delays and with longer (3 to 5 sec) time delays between operator and remote work site. Some of the evaluation and demonstration effort will be conducted jointly with NASA Ames Research Center.

W88-70084 **(10) 506-47**
National Aeronautics and Space Administration, Washington, D.C.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
James P. Jenkins 202-453-2750

This RTOP provides support for the National Academy of Sciences (NAS) Commission on Behavioral and Social Science (CBASS) Committee on Human Factors. The NAS and its committees provide advice to governmental agencies in solving advanced technology problems. The Committee on Human Factors was established to provide advice on determining the most important theoretical and methodological issues in human factors.

Space Flight Research and Technology

W88-70085 **(23) 506-48**
Langley Research Center, Hampton, Va.

SPACE FLIGHT RESEARCH AND TECHNOLOGY
R. R. Nunamaker 804-865-2893

The objective of this research is the development of advanced space systems technologies through a broad-based program of in-flight experimental research. This program provides for data measurement and systems evaluation and verification in the true space flight environment, when such research cannot be adequately accomplished in ground-based simulations or facilities. The approach is to: (1) develop and fly instruments which may use the Space Shuttle orbiter as a research vehicle to obtain data to be used to improve our ability to extrapolate ground-based data and predictions to the actual entry environment for advanced space transportation systems; (2) develop and fly instruments which use the orbiter as an in-orbit test platform on which to conduct experiments to improve our understanding of the orbital environment, the performance of space structures in that environment, and the atmospheric environment; and (3) develop requirements and instrumentation concepts that could be used in extracting in-flight data from a space station.

W88-70086 **(72) 506-48**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
R. L. Woolford 713-483-3022

The Orbiter Experiments Program was initiated to utilize the shuttle as a research vehicle. The objective is to collect data in the technology disciplines that will augment the research and technology base for future spacecraft design. Flight data relative to these disciplines will be collected by utilizing the currently planned TFI/MADS configuration, by modifications and/or augmentation to the DFI baseline, instrumentation and development of unique experiments compatible with the operational capabilities for flight on the Orbiter. Studies will be conducted to determine the optimum method of utilizing the shuttle system to conduct research and technology. These studies will be augmented by investigation to develop experimental programs that would obtain research and technology data in flight regimes applicable to advanced space transportation systems. The primary goal of these studies is more efficient utilization of the Space Transportation System (STS) capabilities to obtain data required to advance the current state of spacecraft technology. This work includes the effort associated with overall project management, project support, experiment development initiation, experiment compatibility assessments, experiment integration activities and integration hardware development initiation. The experiment development efforts are the subject of additional tasks at other appropriate NASA centers.

W88-70087 **(21) 506-48**
Ames Research Center, Moffett Field, Calif.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
J. O. Arnold 415-694-5265
(506-40-00; 506-43-00)

The objective is to utilize the Space Shuttle as a flight research facility to obtain data to support and augment the research and technology base for advanced space transportation systems. A better understanding of thermal protection system (TPS) performance during Orbiter entry will allow creation of options for TPS cost and weight reductions and improved TPS temperature and durability capabilities for the current Space Shuttle and advanced aerospace/hypersonic vehicles. Three separate experiments will be flown as test panels or tiles replacing baseline TPS on the Orbiter during operational flights. These experiments take advantage of the actual entry heating environment that cannot be fully simulated in ground facilities. The experiments will investigate TPS convective heating effects and will demonstrate advanced TPS materials for possible Orbiter retrofit and for application to advanced vehicles. Baseline TPS procedures and instrumentation will be used to the maximum extent practical. There will be no impact on Orbiter operations. These experiments will be designed, developed, and fabricated through both in-house and contract efforts.

W88-70088 **(22) 506-48**
Lewis Research Center, Cleveland, Ohio.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
E. P. Symons 216-433-2853

The program/discipline objective is to provide for the flight verification and evaluation of advanced technologies for future space systems. The program elements contained in this submittal include cryogenic fluid management, and in-space research. The cryogenic fluid management element of the Space Flight research and technology program is focused on developing the technologies required to effectively and efficiently manage subcritical cryogenic fluids in the space environment including the storage, acquisition and transfer of cryogenic fluids. The in-space research element is aimed at providing the evaluation and demonstration of technologies for advanced space vehicles and systems through in-space experiments. Specifically included in the in-space research experiment element is (1) an experiment aimed at achieving technology readiness and user acceptance of a high performance long-life ion auxiliary propulsion system and (2) an experiment aimed at developing the technology base for high temperature heat receiver thermal energy storage materials for advanced solar dynamic power systems operating in microgravity. The overall approach involves performing in-space experimentation to obtain data which can be used to verify analytical models or provide demonstrations of technology readiness.

Systems Analysis

W88-70089 **(10) 506-49**
National Aeronautics and Space Administration, Washington, D.C.
SYSTEMS ANALYSIS
Fred P. Povinelli 202-453-2733

The objective of this RTOP is to provide space program studies in support of OAST space technology program requirements, assessments, planning, and advocacy. The studies are intended to provide an analytical basis for planning activities in space research and technology. Areas of work will include: technology status and trends assessments; mission concepts and systems; long-range planning activities; program technology needs, requirements, and opportunities. A major focus of this activity is the NASA Space Systems Technology Model, including its continual update and maintenance. Activity will also include other study contracts, university grants, and consulting services in support of advanced system concepts and policy analysis issues such as those relating to CSTI, Pathfinder, and potential new or changing roles for OAST in space research and technology.

W88-70090 **(22) 506-49**
Lewis Research Center, Cleveland, Ohio.
SYSTEM ANALYSIS
H. W. Brandhorst 216-433-6149

The objective of Element 2 is to identify, assess, and prioritize high leverage enabling and enhancing spacecraft technologies for NASA and commercial satellites of the mid to late 1990's. For those technologies which are appropriate for further development, as part of the Spacecraft 2000 Program, where appropriate, long range program development plans will be formulated. The approach calls for liaison with industry in addition to both in-house and contracted studies of spacecraft, to surface those programs which have potential for significant benefits. Preparing for the possible Spacecraft 2000 initiative and coordinating the work will be a major part of this effort. The objective of Element 3 is to define and develop system level technology requirements for advanced power systems and to evaluate the impact of these systems if implemented on evolutionary Space Station, Lunar and Mars missions. The results of these studies will be used to develop evolutionary power systems requirements data bases and to identify high payoff technologies.

W88-70091 **(23) 506-49**
Langley Research Center, Hampton, Va.
SYSTEM ANALYSIS
R. R. Nunamaker 804-865-2893

The technical objectives of this research are to identify technology requirements for advanced space systems and to synthesize these requirements into comprehensive and timely technology development plans; to advocate research and technology development programs which satisfy these requirements; and to support conceptual design and development of future spacecraft, advanced earth- and space-based transportation vehicles, lunar and planetary transportation systems and large space antennas, platforms, and space stations via system-level analyses and supporting flight research. In-house and contracted analytical capabilities and computational and experimental facilities will be utilized to accomplish these objectives. Computer-aided engineering, design, and simulation capabilities will be expanded to meet the analysis and technology assessment needs.

W88-70092 **(72) 506-49**
Lyndon B. Johnson Space Center, Houston, Tex.
SYSTEMS ANALYSIS
J. W. Alred 713-483-6615

A primary objective of this task is the development of systems requirements and conceptual designs of space vehicles that are required from earth to orbit, orbital transfer, or lunar descent and/or ascent and the definition of the associated operational requirements. This study will incorporate the data base developed by previous studies on this subject, which will allow a more in-depth effort. This study will establish advantages and disadvantages of using transportation nodes, which will include linear programming models of lunar transportation systems. The study should identify any unique requirements in the Civil Needs Data Base (CNDB) with particular emphasis on lunar base requirements. A preliminary design of a lunar base will be made. In the design, critical factors will be identified, design requirements will be generated, parametric studies will be conducted, interface requirements will be generated and necessary technological developments will be identified.

W88-70093 **(62) 506-49**
Marshall Space Flight Center, Huntsville, Ala.
SYSTEMS ANALYSIS
R. F. Nixon 205-544-5033

The objective of this effort is to define transportation technologies required to support advanced earth orbit, planetary exploration, lunar, and Mars missions. The definition is to include a selection or listing of the technology, the description, and the benefits or rationale. The benefits should show the effect on performance, weight, cost and other appropriate comparative factors. Further, the definition should include a development plan showing the development steps to be taken, the schedule for these, and the funding required. Facility needs should also be identified. The approach is to prepare reference descriptions for each mission case, preferably from existing documentation. Critical vehicles most benefiting from technology are to be selected from these descriptions. That technology most benefiting these vehicles is to be determined and described.

W88-70094 **(21) 506-49**
Ames Research Center, Moffett Field, Calif.
SYSTEMS ANALYSIS
W. Arnold 415-694-6547
(506-43-00; 506-45-00; 159-41-00)

The objective is to identify critical system and subsystem technology requirements associated with future astrophysics payloads such as the Large Deployable Reflector, the Space Infrared Telescope Facility, and second generation instruments for missions like the Hubble Space Telescope and Advanced X-Ray Astrophysics Facilities. The technical complexity of these facilities and instruments, the need for assembly and refurbishment at the space station and the extended lifetime of these missions (10 to 20 years) all represent major areas of uncertainty in system planning and design. Many of the large astrophysics spacecraft planned for the next 10 to 20 years will be so large that ground system test will not be possible. Work will continue on the integration of the unique design tools required for telescope and instrument simulation. The work is divided into three principle areas. The first area will be a study of the designs and technologies required to allow space station based replacement and refurbishment of cryogenic instruments. The second area will involve the integration of telescope unique design tools. The third effort will involve the study of the long term effects of the space environment on detectors and sensors. A new effort will be to survey ongoing and potential research in the reverse engineering of natural systems applicable to advanced aerospace systems.

W88-70095 **(55) 506-49**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SYSTEMS ANALYSIS
John Mankins 818-354-4116

The objective is to identify critical technology needs for future high priority NASA missions, and assist in the formulation of the necessary supporting technology development programs. Studies will focus on technically demanding missions requiring new and enabling technologies (the Mars Rover/Sample Return (MRSR) mission, and extra-solar planetary system detection and characterization), as well as an assessment of the mission impact of new high temperature superconductor material technologies. Trade studies will be conducted to quantitatively define mission/technology options; for the MRSR case, studies will be conducted as part of the larger MRSR study. Analytical models will be used to assess various concepts. To ensure the achievement of greatest scientific return and maximum cost effectiveness, technological approaches will be carefully evaluated in terms of capability, performance, risk, and cost. Resulting information on the benefits, costs, and development plans/schedules for each of the technologies considered, will be presented to NASA program managers.

W88-70096 **(51) 506-49**
Goddard Space Flight Center, Greenbelt, Md.
SYSTEMS ANALYSIS
D. S. Friedman 301-286-6242

The objective of this program is to identify and coordinate technology advances which will enhance or enable earth observing missions. The approach used will be to perform spacecraft system analysis for the evaluation of technology issues, approaches, and overall system benefits.

University Space Research

W88-70097 **(10) 506-50**
National Aeronautics and Space Administration, Washington, D.C.
UNIVERSITY SPACE RESEARCH
Frederick P. Povinelli 202-453-2733

The objective of this effort is to provide for university activities in support of the Space Research and Technology program. These activities include the University Space Engineering Research Program.

NASP-Hypersonics Research and Technology-Space

W88-70098 **(21) 506-80**
Ames Research Center, Moffett Field, Calif.
NASP-HYPERSONICS RESEARCH AND TECHNOLOGY-SPACE
James O. Arnold 415-694-5265
(505-80-00; 763-01-00)

The objective is to provide advanced technologies on a schedule consistent with the needs and requirements of the

NASA/DOD National Aero-Space Plane (NASP) Program. Key research and technology efforts are required in the following areas: (1) propulsion, to provide mature high-speed propulsion technologies in areas such as scramjets, engine components, and complete engines; (2) aerodynamics (including computational fluid dynamics), to provide insight into the stability and control of vehicle concepts, the aerothermodynamic environment to which the airframe will be exposed, the complicated flow fields about the vehicle and at crucial locations such as the inlet of engines and vehicle afterbodies, and integration of the high-speed propulsion system with the airframe itself; (3) structures and materials, to provide characterization of a select group of advanced high-temperature/high-strength materials and verification of their applicability to hypersonic structures concepts, and cryogenic tankage concepts; (4) flight systems, to establish flying quality requirements and to develop guidance, navigation, and control methodologies required to meet NASP performance objectives and mission goals; (5) systems integration which provides the methodology for and the assessment of the performance levels of particular subsystems or components on overall vehicle performance.

W88-70099 **(23) 506-80**
Langley Research Center, Hampton, Va.
NASP-HYPERSONICS RESEARCH AND TECHNOLOGY-SPACE
H. Beach 804-865-3285
(505-80-00; 763-01-00)

The objective is to provide advanced technologies on a schedule consistent with the needs and requirements of the NASA/DOD National Aero-Space Plane (NASP) Program. Key research and technology efforts are required in the following areas: (1) propulsion, to provide mature high-speed propulsion technologies in areas such as scramjets, engine components, and complete engines; (2) aerodynamics (including computational fluid dynamics), to provide insight into the stability and control of vehicle concepts, the aerothermodynamic environment to which the airframe will be exposed, the complicated flow fields about the vehicle and at crucial locations such as the inlet of engines and vehicle afterbodies, and integration of the high-speed propulsion system with the airframe itself; (3) structures and materials, to provide characterization of a select group of advanced high-temperature/high-strength materials and verification of their applicability to hypersonic structures concepts, and cryogenic tankage concepts; (4) flight systems, to establish flying quality requirements and to develop guidance, navigation, and control methodologies required to meet NASP performance objectives and mission goals; (5) systems integration which provides the methodology for and the assessment of the performance levels of particular subsystems or components on overall vehicle performance.

W88-70100 **(22) 506-80**
Lewis Research Center, Cleveland, Ohio.
NASP-HYPERSONICS RESEARCH AND TECHNOLOGY-SPACE
L. A. Diehl 216-433-2438
(505-80-00; 763-01-00)

The objective is to provide advanced technologies on a schedule consistent with the needs and requirements of the NASA/DOD National Aero-Space Plane (NASP) Program. Key research and technology efforts are required in the following areas: (1) rocket propulsion, to provide mature technologies in areas such as 2D nozzles, high thrust to weight, long life, ignition, combustion performance, nozzle performance and multiple engine systems test and control; and (2) fuel system thermal management, to provide mature technologies in areas such as para-to-ortho conversion of hydrogen, thermal properties code, vehicle thermal management codes, subsystem thermal management codes, component codes, enhanced heat transfer technologies. The research and technology efforts will be accomplished using both experiments and analysis.

Interdisciplinary Technology

W88-70101 **(10) 506-90**
National Aeronautics and Space Administration, Washington, D.C.
INTERDISCIPLINARY TECHNOLOGY
Edmund L. Sanchez 202-453-2790

The objective of this effort is to provide for university activities in support of the Space Research and Technology program. These activities include the University Space Innovative Research program and the Resident Research Associateship (RRA) program. The RRA program is administered by the National Research Council of the National Academy of Sciences under contract to NASA. The university activities will be implemented through various grants.

Civil Space Technology Initiative (CSTI) Program

CSTI-Automation and Robotics

W88-70102 **(21) 549-02**
Ames Research Center, Moffett Field, Calif.
CSTI - ROBOTICS
H. Bailey 415-694-6544
(549-03-00)

The objective is to develop and test control and human interface strategies for free-flying, autonomous intelligent robots which will obtain the maximum level of productivity from an astronaut team. Through the development and utilization of intelligent robots, a single human will be able to accomplish a larger set of complex tasks and use his/her intellect to solve problems rather than concentrate on and execute repetitive, labor-intensive tasks. Current emphasis is on the real-time control of mobile, two-arm Satellite Robot Simulator Vehicles (SRSV) and on the development of intelligent work stations for integration with the Telerobotics Test Bed/Demonstration at NASA/JPL. The basic SRSV systems research is being conducted at the Stanford University Aerospace Robotics Laboratory in collaboration with DARPA and NSF. Current research elements include: autonomous navigation and task level control of satellite robots, real-time control of cooperating arms, and object manipulation strategies. In addition, a research effort has been initiated at Stanford University (Departments of Computer Science and Aeronautics and Astronautics) to integrate the AI research with the robotics research focusing towards the development of an intelligent robot within five years.

W88-70103 **(62) 549-02**
Marshall Space Flight Center, Huntsville, Ala.
CSTI - ROBOTICS
J. B. Haussler 205-544-0762

The overall objective of this research is to provide development of the highly experimental technology of telerobotics for orbital assembly and servicing of a space station, platforms, and satellites. This research is focused on developing methodology for evaluation and selection of telerobot systems and demonstrations using scaled test tasks and quantitative measurements. The effort will develop sensored task simulators with graduated difficulty and quantitative measurements which can be used in a test methodology for evaluation of telerobotic demonstrations and systems.

W88-70104 **(55) 549-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CSTI - ROBOTICS
Wayne R. Schober 818-354-8581
(506-44-00; 549-00-00)

The general objective is to develop the technology base required in teleoperators, teleoperator human factors, artificial intelligence, and robotics. This will include automated manipulation, sensing, control and actuation technology required for future NASA telerobotics applications. Example applications are space assembly,

space construction, satellite servicing, space exploration and platform maintenance and repair. The areas of technology will span from operator interface to the end effectors (hands) of the robot and will include: (1) sensing and perception, (2) planning and reasoning, (3) control execution, (4) operator interface, and (5) system architecture and integration. The general approach has two parts: (1) develop core technology which has multiple applications in automation and robotics, and (2) focus the technology on a series of telerobotics demonstrations in 1989, 1991, 1993, 1997 and 2000 to integrate and accelerate transfer of the diverse technologies through ground-based system proof-of-concept. The telerobotics demonstrations will integrate core technologies to provide system level, ground based, proof-of-concept demonstrations of telerobotics capability.

W88-70105 **(23) 549-02**
Langley Research Center, Hampton, Va.
CSTI - ROBOTICS
J. F. Creedon 804-865-4915

The objective of the activity is to provide automated manipulator, mobility, sensing, and actuation technology needed for future NASA teleoperation and robotics applications such as satellite servicing, maintenance and repair, structural assembly, and space manufacturing. The development and evaluation of optical sensing/processing are additional objectives of this research. The approach is to conceptualize, evaluate, and verify algorithms, sensors, actuators, software, and system architecture required for remote space operations. The research will be conducted through simulation and laboratory hardware experimental tests. The current plan is to investigate cooperative human/machine control of manipulator systems and to augment the human teleoperator control through the application of advanced control technology to automate the system, elevating the operator to higher levels of supervisory control.

W88-70106 **(51) 549-02**
Goddard Space Flight Center, Greenbelt, Md.
CSTI - ROBOTICS
H. Friedman 301-286-6185

This work is directed at creating the ability for autonomous robots to generate their own plans for disassembly, assembly, and servicing of complex assemblies, using computer aided design (CAD) derived geometric knowledge bases and spatial reasoning. Laboratory robots execute plans and use sensor feedback to accommodate real-world errors and uncertainties. The program also deals with principles of designing satellites and payloads to be compatible with the use of robots for assembly and servicing. Sample manipulation tasks are evaluated in hardware tests and in software/graphics simulations. Spacecraft and instrument systems are analyzed to derive optimum techniques and scenarios for robotic assembly/disassembly.

W88-70107 **(10) 549-02**
National Aeronautics and Space Administration, Washington, D.C.
CSTI - ROBOTICS
Lee B. Holcomb 202-453-2747

The purpose of this RTOP is to conduct space operations research with particular emphasis on: (1) human capabilities assisted by various levels of automation; and (2) integration of automated robotic capabilities into a planetary rover. The research on the first objective will be conducted by developing and testing a beam assembly teleoperator (BAT) for use in neutral buoyancy tests. Also, tests will be conducted of closed cabin free flyers, head up displays for control of maneuvering units, simulation of telepresence technology, investigation of the human function in supervisory control and the investigation of expert systems for task assignment and housekeeping aboard a space station. This work will be carried out under a grant to the Massachusetts Institute of Technology (MIT). The research on the second objective will be carried out by developing and testing a one-G model of a planetary rover. This work will be carried out under a grant to Carnegie Mellon University.

W88-70108 **(76) 549-03**
John F. Kennedy Space Center, Cocoa Beach, Fla.
CSTI - AUTONOMOUS SYSTEMS
J. R. Jamieson 305-867-3224

The objective of this work is to provide the Systems Autonomy Development Program with the development of diagnostics and control software that will be demonstrated on actual shuttle launch processing ground systems hardware similar to electromechanical systems to be used on the space station. Development of core technology diagnostics and control software has been underway at Kennedy Space Center (KSC) for four years. There have been two parallel software developments underway at KSC. The Knowledge-based Autonomous Test Engineer (KATE) control and monitor shell, which uses a frame-based, source/path/sink structure; and the Generic Model-Based Diagnostic System (GMODS) software which uses an object-based structure. During late 1987, the lessons learned from the GMODS project will be incorporated into more comprehensive (from a functionality viewpoint) KATE shell, and the KATE shell will be used and improved for future demonstrations and operational systems. The objectives of the KSC project are to improve efficiency of the existing KSC launch processing system, to reduce the manpower required to process the shuttle, and to increase the reliability of the system and the process so the proposed heavy launch rates can be better accommodated, as well as developing diagnostics and control concepts for the space station ground processing system and future launch vehicle ground systems.

W88-70109 **(51) 549-03**
Goddard Space Flight Center, Greenbelt, Md.
CSTI - AUTONOMOUS SYSTEMS
J. Friedman 301-286-8623

The overall objective is to research and develop the basic technologies of knowledge-based systems required to achieve successfully higher levels of autonomous activity in command and control systems both on the ground and in space. The immediate testbed for these technology developments will be near-earth spacecraft control ground/space systems. The general approach will be to develop advanced system architectures incorporating multiple knowledge-based systems which operate in a coordinated and cooperative fashion to achieve operational system objectives.

W88-70110 **(62) 549-03**
Marshall Space Flight Center, Huntsville, Ala.
CSTI - AUTONOMOUS SYSTEMS
J. B. Haussler 205-544-1762

The overall objective is to develop techniques for construction of large-scale knowledge bases which can be used to support multiple knowledge based applications, and for capture of design/engineering knowledge. These techniques will be applied to the Hubble Space Telescope (HST) as a testbed for verifying their effectiveness. This approach is based on the principle that research into the use of knowledge engineering technology will be most effective if it is done in the context of a real world application.

W88-70111 **(23) 549-03**
Langley Research Center, Hampton, Va.
CSTI - AUTONOMOUS SYSTEMS
J. F. Creedon 804-865-4915

The objective of this activity is to increase the technology of planning and reasoning automation needed for future NASA space and ground-based operations. In particular, this activity will examine new approaches to planning and scheduling problems, and will develop the methodology required to build validatable knowledge-based systems. The approach is to examine the planning and scheduling requirements of NASA, to evaluate available planning/scheduling software in light of these requirements, and to examine the use of competition-based connectionist systems as a domain-independent framework for planning/scheduling solutions. Additionally, quantitative parameters will be defined to characterize the effects of an embedded knowledge-based system on the total system reliability. Analytical

error models and/or simulative techniques will be developed for measuring these parameters. Guidelines will be developed for designing validatable knowledge-based systems. A methodology and tools for quantifying the reliability of these systems will be developed.

W88-70112 **(72) 549-03**
Lyndon B. Johnson Space Center, Houston, Tex.
CSTI - AUTONOMOUS SYSTEMS
J. F. Muratore 713-483-0796

The objective of this project is to introduce emerging information systems technologies in a real operational environment for monitoring the shuttle. These technologies will be evaluated for their utility in both reducing required manpower for monitoring the shuttle and for increasing the quality of the flight decision-making process. The technologies selected include rule based expert system technology, high resolution color graphics, commercial off-the-shelf UNIX based workstation and data evaluation tools, and telemetry processing and display equipment. All of these technologies will be integrated into a flight controller workstation. This workstation will be capable of autonomously performing a significant percentage of the shuttle monitoring task. The workstation will initially be demonstrated in the laboratory, and then moved to the flight control room in Mission Control for evaluation in mission simulation and actual flight. The expert system will be directly connected to real-time telemetry information so that it may perform on-line diagnostic tasks in real time. Another major element of this approach will be the use of conventionally programmed fault detection algorithms to screen data prior to its use by the expert system. Johnson Space Center will develop the system and evaluate it in real-time operations. Ames Research Center will provide guidance on selection of expert system technologies for use in the workstation.

W88-70113 **(55) 549-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CSTI - AUTONOMOUS SYSTEMS
David Schober 818-354-2555
(450-14-01; 450-17-01; 549-02-00)

The objective of this task is to develop and demonstrate technologies which enable and enhance the multi-mission capabilities of ground data systems for spacecraft and scientific instruments. This task will develop automated tools commonly applicable to spacecraft telemetry and operations ground data systems. Techniques will be developed for automated real-time monitoring and diagnosis functions. A long term objective is to develop technology which enables integration of uplink and downlink operations. The long-term task is divided into two steps: the development of automated telemetry monitoring functions, and the application of these functions to spacecraft subsystems in a demonstration parallel to operations. A series of demonstrations of increasing automated capability are planned. With the objective of a demonstration during the Voyager encounter of Neptune, initial work will focus on automated monitoring of spacecraft telemetry with subsequent extension to ground data systems and spacecraft instruments. The products of the task will be software demonstrations of automated monitoring and diagnosis capability which are ready for operational use. The demonstrations will provide technology which may be extended to remote operations of scientific instruments.

W88-70114 **(21) 549-03**
Ames Research Center, Moffett Field, Calif.
CSTI - AUTONOMOUS SYSTEMS
H. Bailey 415-694-6544
(506-45-00; 506-47-00)

The objective is to develop technologies in artificial intelligence and information sciences leading to an advanced machine intelligent system for spaceborne applications. Emphasis is in the areas of spaceborne symbolic processing architectures, machine learning, advanced planning and scheduling, cooperating knowledge-based systems, operator interface, validation of knowledge-based systems and knowledge from design through operations. A cooperative Ames-academia-industry team consisting of leading researchers has been established. Through a memo of understanding with project centers, such as NASA/JSC and NASA/GSFC, technologies will be transferred to project applications such as Space Station and Space Shuttle. In addition, the Systems Autonomy Demonstration Program (SADP) will transfer the basic research technologies to real-time mission operations environments. The SADP will increase user confidence/acceptance of new technologies and provide a focus for the research efforts to assure their relevance to NASA problems. Program objectives are: decrease of manpower intensive tasks by at least 50%; decrease of documentation for failure diagnostics by at least 80%; and, increase in productivity by at least 20%.

W88-70115 **(22) 549-03**
Lewis Research Center, Cleveland, Ohio.
CSTI - AUTONOMOUS SYSTEMS
H. W. Brandhorst 216-433-6149

The objective of Element 1 is to provide program support to the Systems Autonomy Demonstration Program (SADP) by carrying out the Power Systems Autonomy Demonstration (PSAD), which is an element of the 1990 System Autonomy Demonstration. This is the second in the SADP series of demonstrations that apply advanced automation technologies to Space Station systems. This program is suballoted from Ames Research Center and focussed to highlight benefits of applying advanced automation technologies and core technologies, such as planning and scheduling, energy/power resource allocation, fault diagnosis for anticipated failures, rule based simulation, coordination control of the Electrical Power System (EPS) at LeRC and the Thermal Control System (TCS) at JSC. Also included will be the Core Module (CM) at MSFC with interaction at the LeRC EPS. This demonstration project will be a joint cooperative effort between research and operational NASA Centers: ARC, LeRC, and MSFC. The required artificial intelligence (AI) technologies will be developed and implemented by knowledge engineers and AI and human factors researchers at ARC, while relying upon the EPS domain experts, knowledge and integration, and mission operations personnel residing at LeRC. Additional support to LeRC relating to more specific AI methodologies for space power will be provided by MSFC.

CSTI-Propulsion

W88-70116 **(22) 582-01**
Lewis Research Center, Cleveland, Ohio.
EARTH-TO-ORBIT
D. A. Petrash 216-433-2439

The objective of this RTOP is to provide the technology base, validation of analytical models and verification of advanced design concepts for high performance and safe reusable Earth-to-orbit propulsion systems. Included are future hydrogen/oxygen and hydrocarbon/oxygen propulsion systems with emphasis on autonomous ground and flight operations.

W88-70117 **(62) 582-01**
Marshall Space Flight Center, Huntsville, Ala.
EARTH TO ORBIT
R. J. Richmond 205-544-4935

The purpose of this RTOP is to extend and further develop the earth-to-orbit propulsion technology base in support of current and future space transportation systems. The technology described herein encompasses both oxygen/hydrogen and oxygen/hydrocarbon propulsion and is directed at enhancing engine life, performance and operability. The activity is divided into two categories: technology acquisition and technology validation. Technology acquisition activities include analytical model development, performance improvement, cold flow testing, combustor cooling, turbine drive gas generation, control system analysis, materials and process synthesis, and advanced instrumentation development. The technology validation effort is subdivided into four areas: large-scale combustor components,

large scale turbomachinery components, controls and monitoring subsystems, and oxygen/hydrogen engine systems testbed. The technology advancements emanating from the technology acquisition activity will receive a final degree of validation by testing on a large-scale component, control and monitoring subsystem or on the oxygen/hydrogen engine system testbed.

W88-70118 **(62) 582-02**
Marshall Space Flight Center, Huntsville, Ala.
BOOSTER TECHNOLOGY
R. J. Richmond 205-544-4935

The effort described herein is directed toward developing and enhancing those technologies that will provide propulsion alternatives to the Shuttle solid rocket booster. These alternatives must have an emergency shut-down capability and an increased total impulse capability. Technology for two concepts is being pursued, pressure-fed oxygen-hydrocarbon propulsion and hybrid propulsion. The technology for pressure-fed propulsion is focused on high thrust, high chamber pressure, reusable systems. The specific activities include combustion modeling for both performance and stability, combustion chamber and nozzle cooling, fuel densification through gelling and metallizing, gas generation for tank pressurization and thrust vector control. The technology for hybrid propulsion is also focused on high thrust, high chamber pressure, reusable systems. The specific activities include fundamentals of the liquid oxidizer-solid fuel grain reaction, recession rates, grain tailoring, grain structure, port sizing and design, ignition, oxidizer injection and distribution, thrust vector control and thrust scaling law formulation and verification.

W88-70119 **(23) 582-02**
Langley Research Center, Hampton, Va.
BOOSTER TECHNOLOGY
R. R. Nunamaker 804-865-2893

The technical objective of this research is to assess the technologies for alternate propulsion concepts for the Space Shuttle solid rocket boosters having a safe abort option and the potential for enough additional impulse to avoid the need to operate the space shuttle main engine (SSME) engines at over 100 percent thrust. In this activity, the existing systems analysis capability at Langley will be used to assess the performance improvements/ penalties of these candidate systems.

CSTI-Vehicle

W88-70120 **(23) 583-01**
Langley Research Center, Hampton, Va.
AEROASSIST FLIGHT EXPERIMENT
R. R. Nunamaker 804-865-2893
(906-63-00)

The objective of this project is to develop an in-space flight experiment that will provide validated technology for the design of future Aeroassisted Orbit Transfer Vehicles. Instrumentation is being defined and developed to obtain measurements at actual flight conditions, which cannot be simulated by ground-based facilities, and to obtain flow field information which cannot be determined by validated analysis. The instrumentation will be integrated into the AFE spacecraft and the flight will be conducted to maximize the science return such that technology needs for computational fluid dynamic (CFD) code validate (radiative heating, wall catalysis, alternate thermal protection material, and base flow) can be satisfied and the aerodynamic and control phenomena of this generic shape can be assessed.

W88-70121 **(62) 583-01**
Marshall Space Flight Center, Huntsville, Ala.
AEROASSIST FLIGHT EXPERIMENT
L. B. Allen 205-544-1917

The overall objective of this effort is to provide for the necessary research and technology developments for the Aeroassist Flight Experiment (AFE) to permit investigations of critical vehicle design and environmental technologies applicable to the design of an aeroassisted orbital transfer vehicle (AOTV). Aeroassist technology significantly enhances the orbital transfer vehicle (OTV) mission performance. Because the aerodynamic braking maneuver will only penetrate the upper regions of the Earth's atmosphere at or near geosynchronous return velocities, the AFE will provide design environments that cannot be simulated in ground facilities or determined through analysis. It is necessary, therefore, to obtain critical aerodynamic and aerothermodynamic environments for adequate flight control and thermal protection systems designs for the AOTV. These environments are subject to atmospheric variations that also influence guidance logic for successful rendezvous in low-Earth orbit. Four NASA centers are involved in the project, with Marshall responsible for overall project management, carrier vehicle development, and spacecraft integration. Johnson Space Center is responsible for the aerobrake design and fabrication, as well as experiment development with Langley Research Center, and Ames Research Center is responsible for development of other major experiments.

CSTI-Information Technology

W88-70122 **(51) 584-01**
Goddard Space Flight Center, Greenbelt, Md.
SCIENCE SENSOR TECHNOLOGY
H. Friedman 301-286-6185
(506-44-00)

The objectives of this research are to develop and validate advanced sensor technology required for planned future space science and earth applications missions. Research is being conducted in four areas. (1) Components for a compact high resolution heterodyne spectrometer system in the 500 to 3000 GHz region are being developed for the large deployable reflector submillimeter astronomy facility. These include optically pumped submillimeter laser local oscillators and new low-noise wide-bandwidth high electron mobility transistor pre-amplifiers (HEMT). (2) Arrays of very sensitive and wideband interdigitated electrode photoconductor mixers are being developed for imaging spectrometer applications in the spectral region from 30 to 200 micrometers. (3) Multicolor, picosecond-pulse, solid-state laser transmitters and picosecond-resolution streak camera time interval receivers are being developed for the spaceborne geoscience laser ranging and altimetry system (GLRS) on the EOS facility. (4) Long-life spaceborne cryogenic cooler subsystems are being developed to meet requirements of new sensing instruments over the spectrum from millimeter to gamma-ray wavelengths which must operate at temperatures below 10 K. Subsystems include long-life cold bearings and low temperature regenerators with magnetic materials.

W88-70123 **(62) 584-01**
Marshall Space Flight Center, Huntsville, Ala.
SCIENCE SENSOR TECHNOLOGY
J. B. Haussler 205-544-1762

The objectives of this effort are threefold: (1) conduct CO2 laser research for space-based lidar application; (2) investigate the problem of space debris detection; and (3) perform investigations into cryogenic coolers and superconducting array detectors. The planned approach incorporates both in-house and contractual efforts to arrive at the desired objectives.

W88-70124 **(22) 584-01**
Lewis Research Center, Cleveland, Ohio.
SCIENCE SENSOR TECHNOLOGY
Denis J. Connolly 216-433-3503
(506-44-00)

The objective of this RTOP is to provide through research, design data and developments of materials and methods, the technology base for the development of voltage tunable local oscillator sources, capable of approximately 1 milliwatt output in the frequency range between 600 to 2000 GHz. The approach

taken pursues the development of voltage tunable, electron beam excited backward wave oscillators (BWO), with an expected frequency tuning range (by voltage tuning) of approximately +/- 10 percent above and below a center frequency. Because of the extreme smallness of slow wave structures dimensions (less than 50 microns) new methods of fabricating BWO circuits must be explored. These include reactive ion etching, laser cutting and metallization techniques. In addition, skin effect losses and direct interception will necessitate novel approaches for heat rejection.

W88-70125 **(23) 584-01**
Langley Research Center, Hampton, Va.
SCIENCE SENSOR TECHNOLOGY
W. D. Mace 804-865-3745

The objective of this program is to develop all solid-state components for versatile active remote sensors supporting high-flying aircraft and space-based earth science investigations in atmospheric dynamics and chemistry. The most important of these sensors are light detection and ranging (lidar) and differential absorption lidar (DIAL) systems. This research and technology program has been structured to approach these challenges in the areas of laser materials research, laser transmitter design and development, lifetime and efficiency improvement through in-house, university grant, and industrial contract efforts.

W88-70126 **(21) 584-01**
Ames Research Center, Moffett Field, Calif.
SCIENCE SENSOR TECHNOLOGY
C. R. Bailey 415-694-6549
(506-45-00; 506-49-21)

Advanced infrared (IR) detector array technology, and advanced detection concepts which promise to provide future IR arrays, will be developed and characterized. These arrays will be applicable in low- and moderate-background missions such as the Space Infrared Telescope Facility (SIRTF) and the Large Deployable Reflector (LDR). The goal is to achieve enhanced IR spectral response (to and beyond 200 micrometers) and improved sensitivity in anticipated orbital environments. Advanced low-noise multiplexer, impurity band conduction, and improved 30 micrometer array technology will be pursued. A second objective is to develop and demonstrate advanced cryogenic systems for future space applications. These coolers are required to have a high efficiency, low cost, an extended life, and good temperature stability. In some applications the coolers must allow the instruments to be serviced and/or replaced on orbit. Elements of this objective include pulse tube refrigerators, a 2 to 15 Kelvin cooler, and advanced coolers for less than 1 kelvin operation. These activities blend analysis with component development, and include extensive in-house characterization, development, and technology demonstrations.

W88-70127 **(55) 584-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SCIENCE SENSOR TECHNOLOGY
Arthur Schober 818-354-6457
(506-45-00)

This work is to advance the fundamental principles which form the basis of the sensing of radiation as well as to produce experimental detectors. The approach is to maintain parallel device research and device development activities in a broad range of the electromagnetic spectrum extending from the submillimeter regime to the visible. Some of the activities are continuations of sensor work previously conducted under the base program and now made a part of the CSTI activity. Examples are the sub-mm oscillator, SIS mixer material development and array work as well as Si compatible IR sensor development which had been of the materials support activity. New programs include two non-coherent IR programs, one building upon the extensive progress made by the military in the area of II-VI detector materials for use in the 5-15+ micron range and the second based on Ge Bound Impurity Band (BIB) approach for the 30 to 300 micron range. Both are expected to result in detector arrays specifically designed to satisfy NASA needs in the next 4 to 7 years but derived from technology originally directed at other applications. These radiation detectors operate at cryogenic temperatures ranging from less than 1 K to 100 K. To satisfy NASA needs for long life, low power and weight requirements, reliability, etc., new research on coolers will begin. Three separate development efforts will be made to attempt to satisfy the divergent detector needs and temperature ranges.

W88-70128 **(23) 584-02**
Langley Research Center, Hampton, Va.
DATA: HIGH RATE/CAPACITY
W. D. Mace 804-865-3745

The objective is to research new concepts in space data processing and storage. This concept development will result in planning, development, and delivery of technology research and development studies, system feasibility models, and prototype proof of concept hardware in support of NASA's mission, including advanced aerospace transportation vehicles, space station, co-orbiting platforms, polar-orbiting platforms, and deep space payloads, in the areas of data systems. The approach is to use mission identified needs, together with new device and systems technologies in high-speed, space qualified processors, and high rate/capacity optical storage systems, and analyses to provide an enabling and enhanced system level performance. In particular, elements will be researched and developed through the proof of concept phase, and this technology will be delivered for mission projects where appropriate. Individual tasks included are very high scale integrated circuit (VHSIC) processor technology, erasable optical media, laser diode arrays, multichannel controller, optical disk drive, fiber optic integrated circuit transceivers, and distributed computing strategies.

W88-70129 **(55) 584-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DATA: HIGH RATE/CAPACITY
David A. Nichols 818-354-8912
(506-44-00; 506-45-00)

The objective and approach of this effort is to provide research and technology development for specific high rate and high capacity space flight data system components. Many of the space science missions being planned for the mid-1990s and beyond will have payloads capable of producing extremely high data rates. Data system technology development included in this effort will both enhance the ability to make more productive scientific use of collected data and enable the deployment of instruments to make new and unique observations. Specific tasks include the development and demonstration of: (1) a next-generation flight computer, capable of greater than an order-of-magnitude increase in throughput over current practice; (2) a synthetic aperture radar (SAR) processor suitable for use on an EOS-type platform capable of near real-time image correlation and data compression; (3) a spaceborne processor capable of radiometric calibration, compression and simple information extraction as applied to imaging spectrometer data; and (4) an autocorrelation spectrometer suitable for use in spaceborne mm-wave and submm-wave radiometers. In each task the goal will be the development of a flight qualifiable prototype which can be used either operationally or experimentally in the Earth Observing System (EOS) program or in other missions.

W88-70130 **(51) 584-02**
Goddard Space Flight Center, Greenbelt, Md.
DATA: HIGH RATE/CAPACITY
J. Dalton 301-286-8623

The objective of this research is the development of an onboard high rate/high capacity data system called the configurable high rate processing (CHRP) system suitable for onboard spacecraft processing of sensor data at rates up to 10,000 MIPS. The approach is to develop CHRP capabilities tailorable to fit the needs of many different missions and configurable in real time to adapt to changes in the operating environment. It will provide the total onboard data management support required for scientific operations from instrument interface to communication link transmitters and receivers. This includes all formatting, coding, buffering, processing, editing, storage, and multiplexing required by complex

heterogeneous payloads operating at hundreds of megabits per second. The CHRP system topology is designed to support multiprocessing, including multiple processor types performing simultaneous independent or correlated tasks. The CHRP will build upon the technology base established by OAST investments in the Massively Parallel Processor (MPP), the terabit buffer, GaAs, very high speed integrated circuits (VHSIC), and StarBus. Eight basic elements make up the building blocks as presently envisioned. Six are hardware and two are software. The CHRP development strategy includes an architecture definition element during which alternative computational scenarios will be created and utilized to evaluate the efficiency and flexibility of various architectural options.

CSTI-Large Structures and Control

W88-70131 **(23) 585-01**
Langley Research Center, Hampton, Va.
CONTROL OF FLEXIBLE STRUCTURES
W. D. Mace 804-865-3745

The objective of the NASA control of flexible structures (COFS) technology program is to generate a technology data base that will provide the designer with options and approaches to achieve spacecraft performance such as maintaining geometry and/or suppressing undesired spacecraft dynamics. The COFS program will address analysis and design, ground testing, control methods, and in-space testing to achieve a valid flight-ready technology. The program will be focused on the development of technology required to understand and accurately predict and control deformations of large flexible spacecraft in a microgravity environment. The program will evolve around major ground and generic in-space testing with increasing spacecraft complexity to validate control/structures design methodologies, control approaches, structural analysis methods, and ground and flight test methods. The products of this technology can be made with confidence. The COFS plan is scheduled to begin in-space testing in the early 1990s and to have validated flight-ready control/structures technology by 1995.

W88-70132 **(55) 585-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PRECISION SEGMENTED REFLECTORS
Eugene V. Pawlik 818-354-0086
(159-41-01; 506-49-00)

The objective is to develop the technology needed for the development of large lightweight precision reflectors for space applications. This is the Jet Propulsion Laboratory portion of a joint effort with the Langley Research Center. This program will initially be directed toward providing reflecting surfaces with the precision required for the far infrared region (wavelengths greater than or equal to approximately 75 microns) and then progress toward shorter wavelengths. The long-term goal of this program is to develop a technology base that will enable future missions that are expected to use large, lightweight, low-cost reflectors. The program will develop baseline graphite/epoxy composite one-meter panels, the panel control system necessary to maintain figure control, and test these panels on a representative structure. Technology will be integrated into a testbed demonstration of an actively controlled, segmented reflector that will be operated in four years. It will provide a means of validating the technology and providing a testbed for future technology developments. Alternate panel construction materials will be researched in order to identify promising approaches for advanced composite techniques to improve surface precision and methods will be investigated to extend the panel size up to two meters. Active and passive vibration damping techniques will be developed for the panel support structure.

W88-70133 **(23) 585-02**
Langley Research Center, Hampton, Va.
PRECISION SEGMENTED REFLECTORS
C. P. Blankenship 804-865-2042

The research includes development, fabrication, and testing programs in structures and materials with emphasis on: (1) composite materials and coatings, and (2) deployable and erectable structural concepts. The objective is to develop advanced composite materials and coatings that are durable and have stable thermal and mechanical properties and to develop deployable and erectable structural concepts for applications to precision segmented reflector spacecraft. Analytical, computational, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry.

CSTI-Power

W88-70134 **(55) 586-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIGH CAPACITY POWER
Kenneth L. Atkins 818-354-6293
(506-41-00)

The objective is to develop and demonstrate solid-state thermal-to-electric power conversion technology meeting the demanding requirements of high-density power conversion with long lifetimes (more than 10 years) and high efficiencies (10 to 20 percent) for spacecraft power systems. This will support the overarching high density power theme to keep the volume-percentage of the power subsystem within the bounds of 20 percent of total space system volume. Current state of the art is about 1 W/cu in. The eventual objective is 10 W/cu in. by the year 2000, a factor of 10 improvement. Without progress in light, high-efficiency converters, typical power subsystems could require over 60 percent of total system volume. To enable this achievement will require steady progress in solid state thermal conversion technology avenues to reach conversion efficiencies in the 15 to 20 percent range without moving parts. Approaches will include industrial and university co-op tasks to achieve demonstration elements, with solid analytical support. The major activities will focus on: (1) nearer term doping techniques with silicon-germanium semiconductor materials; and (2) alternative rare-earth semiconductor materials. Basic materials research and theoretical analysis will be the primary tools.

W88-70135 **(22) 586-01**
Lewis Research Center, Cleveland, Ohio.
HIGH CAPACITY POWER
H. W. Brandhorst 216-433-6149

The NASA SP-100 Advanced Technology Program is intended to augment the GES engineering development and ground testing of major subsystems being conducted by DOE and is structured to enhance the chances of success for the overall SP-100 nuclear power system development. The program is focused on providing significant component and subsystem options for increased efficiency, survivability, growth at reduced weights, and higher reliabilities. These goals will be attained through the conduct of the broad based research and technology program which includes the following elements; space missions support; systems analysis to guide the research and technology efforts and to identify the pay-offs; advanced conversion technology development; thermal management; advanced power conditioning and control; space power materials and structures; and spacecraft environmental effects.

Transatmospheric Research and Technology

Aero-Space Plane Technology

W88-70136 **(10) 763-01**
National Aeronautics and Space Administration, Washington, D.C.
RESEARCH AND TECHNOLOGY
Duncan McIver 202-453-2808

The objective of this program is to provide advanced technologies on an orderly and prioritized schedule with the needs and requirements of the joint NASA/DOD National Aero-Space Plane (NASP) program. The NASP program, initiated in 1986, is currently in the concept definition phase (Phase 2), leading to design and development of flight research vehicle (Phase 3). The NASA Transatmospheric Research and Technology program has a major responsibility within the NASP Program for defining and maturing an array of advanced technologies, including possible flight validation, for the X-30 flight research vehicle. This RTOP describes and provides the NASA contribution to the NASP Joint Project Office (JPO) located at Wright-Patterson AFB, Ohio. The JPO further distributes the funding to other government laboratories, industry and universities for support of technology tasks, contracts and grants.

W88-70137 **(22) 763-01**
Lewis Research Center, Cleveland, Ohio.
RESEARCH AND TECHNOLOGY
J. A. Ziemianski 216-433-3901

The objective of this program is to advance those critical technology areas required to support, in a timely manner, the joint DOD/NASA National Aero-Space Plane (NASP) Program. The NASP Program represents a major national effort in defining and maturing the array of advanced technologies including possible flight validation. This RTOP focuses on advancing critical technology needed to solve low speed propulsion, rocket propulsion, and engine structures and materials problems associated with the aerospace plane. The current plans for this research area are to develop aerodynamic analytical codes to evaluate candidate propulsion concepts and components for further refinement and testing, and screen various experimental configurations, and provide technology information for future experiments; develop thermal models for conducting vehicle heat balances and research on cryogenic propellant system thermal management; develop dynamic models for engine structures; and develop select structural concepts and technologies for high speed lightweight and durable propulsion systems.

W88-70138 **(23) 763-01**
Langley Research Center, Hampton, Va.
RESEARCH AND TECHNOLOGY
Harris Alred 804-865-3285
(505-61-00; 505-62-00; 505-63-00; 506-40-00; 506-41-00)

The objective is to provide advanced technologies on a schedule consistent with the needs and requirements of the NASA/DOD National Aero-Space Plane (NASP) Program. Key research and technology efforts are required in the following areas: (1) propulsion, to provide mature high-speed propulsion technologies in areas such as scramjets, engine components, and complete engines; (2) aerodynamics (including computational fluid dynamics), to provide insight into the stability and control of vehicle concepts, the aerothermodynamic environment to which the airframe will be exposed, the complicated flow fields about the vehicle and at crucial locations such as the inlet of engines and vehicle afterbodies, and integration of the high-speed propulsion system with the airframe itself; (3) structures and materials, to provide characterization of a select group of advanced high-temperature/high-strength materials and verification of their applicability to hypersonic structures concepts, and cryogenic tankage concepts; (4) flight systems, to establish flying quality requirements and to develop guidance, navigation, and control methodologies required to meet NASP performance objectives and mission goals; (5) systems integration which provides the methodology for and the assessment of the performance levels of particular subsystems or components on overall vehicle performance.

W88-70139 **(21) 763-01**
Ames Research Center, Moffett Field, Calif.
RESEARCH AND TECHNOLOGY
J. O. Arnold 415-694-5265
(506-40-00; 506-43-00; 505-61-00)

The objective is to mature technologies required for the National Aero-Space Plane (NASP) Program. This work is highly focused and will complement the ongoing research and technology programs (research and technology base). Emphasis will be placed in the areas of propulsion technology, aerodynamics, structures and materials, and flight systems. In propulsion technology, research includes inlet/forebody aerodynamics, direct connect combustor/nozzle experiments, shock tunnel nozzle tests, and the development of a computational fluid dynamics (CFD) code to study the effects of cowl lip bluntness. In aerodynamics, computational chemistry will provide the basic atomic and molecular database required by the CFD codes, and the chemistry will be coupled to flow codes. In materials and structures, research includes temperature control coatings, materials hydrogen compatibility tests, and instrumentation. In flight systems, research includes landing visibility requirements, and simulation model development.

OFFICE OF SPACE SCIENCE AND APPLICATIONS

Global Scale Atmospheric Processes

W88-70140 **146-00-00**
Langley Research Center, Hampton, Va.
GLOBAL ATMOSPHERIC PROCESSES
M. P. McCormick 804-865-2065
(176-00-00)

This RTOP covers several studies of atmospheric processes related to the improvement of global weather prediction. These studies include the development of lidar techniques for airborne/spaceborne remote sensing of atmospheric constituents, such as water vapor, and other meteorological parameters, such as winds. Also included are studies of global atmospheric aerosols and the basic physics required to develop and utilize a Doppler laser wind sounder.

W88-70141 **146-60-08**
Goddard Space Flight Center, Greenbelt, Md.
SATELLITE DATA ASSIMILATION
Wayman Baker 301-286-7509
(146-64-00; 146-65-00)

The objective of this RTOP is to utilize satellite observations of the atmosphere in order to initialize, verify and improve models; diagnose atmospheric processes; assess the impact of satellite data on forecast accuracy; and increase our understanding of atmospheric behavior. The approach will be to develop advanced general circulation models and analysis methods and to utilize satellite data in comprehensive four-dimensional analysis for the atmosphere. The results will be used to perform data impact studies in order to diagnose and understand the dynamics of the atmosphere. Expected results include: (1) utilization by the academic community of the new global fields developed in the four-dimensional analysis; (2) improved general circulation models and analysis methods which can be used for prognostic and diagnostic studies; and (3) theoretical and numerical studies that improve our understanding of global scale atmospheric processes.

W88-70142 **146-61-00**
Goddard Space Flight Center, Greenbelt, Md.
PRECIPITATION REMOTE SENSING RESEARCH
Otto W. Thiele 301-286-9006

The objective of this RTOP is to conduct precipitation remote sensing research which involves: (1) physical processes associated with precipitation; (2) remote sensing techniques; (3) the statistical properties of rainfall; (4) techniques for validating space-based precipitation measurements; (5) field experiments; and (6) the application of space-acquired precipitation data to weather and climate problems. The approach will be to investigate the physical processes and distribution characteristics associated with precipitation, including understanding associated cloud regimes. Techniques will be developed for remote sensing of precipitation from aircraft and satellites, e.g., radar, microwave and visible/infrared radiometers, also including related science for algorithm development. The statistical properties of rainfall will be investigated in order to define sampling strategies in time and space. Ways to improve and interpret in-situ rainfall measurement techniques for developing methods to validate (ground truth) space remote sensing measurements of precipitation will be investigated. Field experiments will be conducted in association with studies of physical processes and the development of algorithms, instrumentation, and ground truth schemes. Scientific investigations will be conducted, including modeling and simulation studies relating to the application of space- and aircraft-acquired precipitation data to weather problems, the hydrological cycle, and climate diagnostics and predictability research. Results are expected to lay the scientific and technical foundation for making, understanding, and applying space-based measurements of tropical and eventually global precipitation to a host of weather, climate, and hydrological problems.

W88-70143 **146-64-10**
Goddard Space Flight Center, Greenbelt, Md.
PROGRAMMATIC SUPPORT
Wayman Baker 301-286-7509

The objective of this RTOP is to support research investigations by the academic community and NASA investigators utilizing FGGE data and to investigate new methods for assimilating satellite data into global circulation models, with the aim of improving our understanding of the causes of El Nino. The approach will be to continue support of outside investigator's proposals for research utilizing the First Global Atmospheric Research Program (GARP) Global Experiment (FGGE) data through peer review of submitted proposals and to investigate novel data assimilation techniques and new data sources for applicability to modeling global scale atmospheric processes. Expected results include improved understanding of the global scale atmospheric processes. A coupled biosphere-atmosphere model should improve our modeling of evaporation processes, and therefore improve our prediction of precipitation over land. A coupled ocean-atmosphere model should improve our understanding of El Nino.

W88-70144 **146-65-00**
Goddard Space Flight Center, Greenbelt, Md.
METEOROLOGICAL PARAMETER EXTRACTION
Wayman Baker 301-286-7509
(146-64-00; 146-60-00)

The objective of this RTOP is to develop new and improved techniques for retrieving useful parameters from satellite-measured radiances and to interpret these retrievals to provide information on the state of the atmosphere. The approach will be to develop advanced methods for satellite temperature retrievals and to conduct research in methods to determine temperature, moisture, and precipitation from measurements of various portions of the electromagnetic spectrum. Expected results include techniques to determine atmospheric temperature and moisture profiles, cloud parameters, and surface parameters; and validation of the retrieval products. Analyses of these data should improve our understanding and prediction of global scale atmospheric processes.

W88-70145 **146-66-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
METEOROLOGICAL PARAMETERS EXTRACTION
M. T. Chahine 818-354-2433
(146-72-06)

The overall objective of the proposed research is the development of accurate numerical analysis methods to retrieve, from satellite data, important meteorological parameters needed for weather and climate studies. To accomplish this we plan to conduct theoretical and applied studies for the development of improved numerical techniques to retrieve atmospheric and surface parameters from radiance data measured by the National Oceanic and Atmospheric Administration (NOAA) High Resolution Infrared Sounder and Microwave Sounding Unit (HIRS/MSU) sounders. We will apply the retrieval methods for simultaneous determination of several meteorological parameters such as clear-column vertical temperature and humidity profiles, sea-surface temperature, and the distribution of cloud heights and amounts. We will verify the accuracy of the results by participation in national and international workshops dedicated to this objective and by comparison with colocated radiosonde and sea-surface data and with cloud nephanalysis obtained independently from other sources. We will apply the results to observe and study various air-surface interaction processes on monthly to seasonal time scales. Simultaneous determination of the atmospheric and surface thermal structure and the cloud distribution provides information on heat sources and sinks, storage rates, and transport phenomena in the atmosphere. Such information is critical in determining the driving mechanisms for motions in the atmosphere and oceans and in improving numerical weather prediction.

W88-70146 **146-66-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL SEASAT WIND ANALYSIS AND STUDIES
P. M. Woiceshyn 818-354-5416

Our research is directed toward the incorporation of high-resolution scatterometer marine wind and wind stress measurements in global meteorological research, applications and prediction, and the development of techniques for dealiasing and assimilating scatterometer wind data into atmospheric and coupled atmosphere-ocean models. The major objectives are: (1) to perform global and regional meteorological research using the dealiased Seasat-A Satellite Scatterometer (SASS) marine wind fields; (2) to continue the study introducing the orthogonal square-root information matrix form (SRIF) computer implementation of the Kalman-type estimation process for application to data analysis and assimilation; and (3) to process SASS data augmenting and enhancing the 15-day data record provided to NASA in September 1983 using algorithms developed by the project (in particular to process SASS windfields for two weeks in July and one week in September, 1978). Case studies of storms of special interest will focus on explosive development, unusual structure, and forecast improvement. Statistics will be developed of meteorological parameters of importance in the global circulation of the atmosphere, including spectral statistics and empirical orthogonal function analyses of surface fields. The application and impact of SASS marine wind data will be studied in equatorial ocean-atmosphere interaction dynamics, global-ocean rainfall estimation, frontal instability, coastal mesoscale phenomena, diabatic marine boundary layer studies, high resolution numerical assimilation and forecast schemes, generation of synoptic pressure fields consistent with scatterometer wind data, and incorporation of these fields in a numerical forecast scheme for 6 to 12 hour forecast periods, using only scatterometer data. There will be collaboration with and use of the algorithms of ECMWF (European Centre for Medium Weather Forecasts) in studies of the impact on numerical weather and wave forecasts of scatterometer wind data.

W88-70147 **146-66-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROGRAM SUPPORT
C. Elachi 818-354-5673

The objective of this RTOP is to provide support to the NASA/Atmospheric Dynamics and Radiation Branch, Earth Science and Applications Division, by providing the services of a Jet Propulsion Laboratory (JPL) detailee to NASA Headquarters.

W88-70148 **146-70-16**
Goddard Space Flight Center, Greenbelt, Md.
METEOROLOGICAL OBSERVING SYSTEM DEVELOPMENT
S. H. Melfi 301-286-6348

The objective of this RTOP is to develop new and improved spaceborne remote sensing systems in support of the NASA Global Weather Program and to develop improved data processing and retrieval techniques to provide for more accurate understanding of processes which influence the state and behavior of the atmosphere. The approach will use theory, laboratory measurements, and field experiments to define, develop, and evaluate new and improved remote sensing techniques to observe profiles of atmospheric temperature, moisture and pressure, precipitation, surface properties, and atmospheric radiative properties. Infrared, visible and microwave, and passive modes will be employed. Evaluation, in cooperation with other scientists, will be performed to assess improvement in weather forecasting. Expected results include improved techniques and instrumentation to observe profiles of atmospheric temperature, moisture and pressure, precipitation, surface properties, and atmospheric radiative properties leading to improved weather prediction.

W88-70149 **146-72-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTERAGENCY TEMPERATURE SOUNDER (ITS)
M. T. Chahine 818-354-6057

The ultimate objective of this effort is to develop a tropospheric and surface temperature sounder, which complements the Advanced Microwave Sounding Unit (AMSU) on the Earth Observing System (EOS), in an effort to meet the requirements of the numerical weather prediction models of the 1990s. Over the past eight years we developed an infrared Advanced Moisture and Temperature Sounder (AMTS), a grating spectrometer using 28 discrete spectral channels, which establishes the highest level of performance achievable with a stand-alone infrared sounder. Unfortunately, the AMTS instrument was physically large and its measurement capability did not receive the unqualified support of the user community, specifically the National Oceanic and Atmospheric Administration National Environmental Satellite Data and Information Service (NOAA/NESDIS). Two recent events have significantly changed this situation. During 1986 a NOAA/NASA 'nteragency Sounder Team was formed, which is currently defining the requirements for an advanced sounder on the Polar Platform, the Interagency Temperature Sounder (ITS). The recent declassification of HgCdTe array technology has opened the exciting possibility of using a grating array spectrometer to meet he ITS measurement requirements. This instrument has the potential of achieving the high performance of AMTS, but with considerably smaller size and with significantly more channels. This RTOP will initiate the design study of a grating array spectrometer for the ITS, in support of the Interagency Sounder Team. The study will support science tradeoffs such as selection of additional temperature sounding channels, selection of channels nd quantitative evaluation of the feasibility of global trace gas monitoring, and signal-to-noise ratio (SNR) requirements; and the rst order design of the array spectrometer.

/88-70150 **146-72-01**
et Propulsion Lab., California Inst. of Tech., Pasadena.
IICROWAVE PRESSURE SOUNDER
. A. Flower 818-354-4151

This RTOP supports the third phase of the Microwave Pressure ounder (MPS) research program, the objective of which is to evelop an instrument for the remote measurement of atmospheric essure at the earth's surface. Extensive design studies have own that differential absorption measurements in the wings of e 60 GHz oxygen absorption band are capable of providing rface pressure observations with the accuracy and coverage suited to applications in global weather research and operational weather forecasting. These theoretical studies have been supported by an experimental program with a simplified instrument on the NASA CV-990 aircraft. Recent results from these experiments have demonstrated the ability to determine surface pressure with an accuracy of 1 millibar. The specific objectives of this phase of the program are: (1) detailed investigation of the limits to the validity of oxygen and water vapor spectroscopic models and the improvements of the models where possible; (2) development and testing of precision calibration techniques and MPS subsystems suitable for use in a satellite instrument; and (3) an investigation of the capabilities of the combined use of active and passive remote sensing instruments for meteorological observations. The approach will be to develop precision calibration techniques and improved MPS subsystems and to test these in the present aircraft instrument. Data acquired with the instrument on NASA's CV-990 aircraft will be used to investigate the limits of the present oxygen and water vapor spectroscopic models. A study will be initiated on the use of passive remote sensors in combination with the MPS instrument to define the advantages of using the sensors in combination with meteorological measurements. Results of these studies will be applied to the design of a satellite MPS.

W88-70151 **146-72-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IR REMOTE SENSING OF SST
D. E. Hagan 818-354-7073

The objective of this research is to understand and describe, from infrared measurements in the 8 to 13 micron range, the propagation of radiation in the atmospheric boundary layer, in order to assess the limiting value of water vapor content for which realistic sea surface radiances can be extracted from spaceborne measurements. The approach is to use a new high precision infrared (IR) radiometer with a measurement strategy that is designed to address the above problem during a series of experimental balloon flights. Vertical path attenuation measurements will be made from a blimp and from an aerostat for wet atmospheric conditions to explore the dependence of the continuum extinction and boundary flux exchange on the partial pressure of water vapor, the total pressure, and temperature. Dr. C. B. Farmer and other members of the Atmospheric and Oceanographic Sciences Section will participate in this research.

W88-70152 **146-72-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TROPOSPHERIC WIND MEASUREMENT ASSESSMENT
R. T. Menzies 818-354-3787
(146-72-10; 146-72-11)

The objective of this program is to evaluate certain aspects of the Doppler laser radar technique for global measurement of tropospheric wind fields. This technique has the potential for providing global wind data from an orbiting platform. Several types of remote measurement of atmospheric wind velocities have been analyzed, e.g., passive microwave, millimeter wave, infrared radiometry, and active visible and infrared range-gated lidar, with the results indicating that the Doppler lidar technique is the superior technique for tropospheric wind field measurements. During FY88, the work will continue on an experimental study of vertical profiles of atmospheric backscatter or CO2 laser wavelengths in the 9 to 11 micron region. This study will be conducted using an existing transversely excited atmospheric pressure (TEA) CO2 lidar facility, employing a single longitudinal mode (SLM) injection controlled TEA laser transmitter and a heterodyne receiver. The use of air parcel trajectory analysis capabilities at the University of California at Los Angeles (UCLA) will be continued in order to study the dependence of aerosol backscatter on the history of the air parcel. Continued experimental studies of the correlation time of the aerosol backscatter signal, which is an important parameter for coherent lidar detection analysis, will be conducted. Comparative performance analysis of the major types of Doppler lidar, including both incoherent and coherent detection, have been conducted and reported in the literature. These studies will be re-assessed as new data and new technology become available.

W88-70153 **146-72-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AMSU RESEARCH STUDIES
R. K. Kakar 818-354-7748

The objective of this investigation is to: (1) optimize the capabilities and specifications of the Advanced Microwave Sounding Unit (AMSU), the next generation microwave sounder system for National Oceanic and Atmospheric Administration (NOAA) operational applications; (2) develop techniques for retrieving meteorological parameters from microwave radiometric measurements; and (3) define operational and/or experimental microwave radiometric systems beyond AMSU. The proposed research will consist of radiative transfer studies, numerical simulations, planning and evaluation of field experiments, and the analysis of measured data to verify the feasibility of measuring various meteorological parameters with microwave radiometry. Meteorological parameters to be addressed include temperature and water vapor profiles and precipitation intensity and distribution. The necessary measurement program will be carried out with the airborne Advanced Microwave Moisture Sounder (AMMS) in collaboration with Dr. T. T. Wilheit of NASA Goddard Space Flight Center (NASA/GSFC).

W88-70154 **146-72-06**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ATMOSPHERIC PARAMETER MAPPING
K. J. Hussey 818-354-4016
(146-66-01)

The primary objective is to continue development of the image processing capability to produce very high quality color maps and time-lapse imagery of global atmospheric parameters derived from National Oceanic and Atmospheric Administration (NOAA) High Resolution Infrared Sounder 2 and Microwave Sounding Unit (HIRS2/MSU) satellite data. Other objectives include increasing the cost effectiveness of map production, making the process of climatic map generation and data analysis more readily available to atmospheric scientists, and providing continuing support to M. Chahine in the development of new parameter maps derived from the combination and integration of existing data fields. The approach will be to continue research and production of high quality time series images and global atmospheric parameter maps in a cost effective manner. An upgraded implementation of the Video Image Communication and Retrieval (VICAR) image processing software system and Automated Raster Cartography System (ARCS) will be made operational on the Digital Image Animation Laboratory (DIAL) MicroVAX 2. Time series analysis software will be improved and optimized. Procedures to facilitate the use of the DIAL's computer controlled animation subsystem will be written. The integration of computer graphics and image processing techniques will be investigated as a means of greatly improving the quality of graphic overlay in time series imagery. Animations demonstrating various system improvements will be produced along with a Global Climatological Atlas of Atmospheric Parameters for 1979 under the direction of M. Chahine.

W88-70155 **146-72-09**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ATMOSPHERIC DYNAMICS AND RADIATION SCIENCE SUPPORT
C. Elachi 818-354-5356

The objective of this task is to support the NASA Atmospheric Dynamics and Radiation Branch in the development and scientific use of remote sensing techniques to study atmospheric dynamic phenomena in the lower atmosphere, such as wind fields, pressure fields, and precipitation. The approach will consist of inviting distinguished scientists in the field to spend some time (a few weeks to a few months) at the Jet Propulsion Laboratory (JPL) to work with JPL scientists and to explore new ideas and concepts of direct relevance and interest to the atmospheric dynamics and radiation program.

W88-70156 **146-72-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LIDAR TARGET CALIBRATION FACILITY
R. T. Menzies 818-354-3787
(146-72-04; 146-72-11)

The primary objective of the Jet Propulsion Laboratory (JPL) Lidar Target Calibration Facility is to provide accurate and consistent calibration of CO2 lidar targets. Customers in the lidar community will each provide a sample to JPL of the target surface which is to be used to calibrate the customer's lidar system. Parameters which are used in the lidar calibration, such as the CO2 laser wavelength, incident and reflected polarization, and the polar angle at the target will be specified by the customer. The measurement result provided to the customer for each set of specified parameters will be the target reflectance parameter, which is used in the reduction of hard target and aerosol backscatter data to obtain the desired profile of the aerosol backscatter coefficient. A secondary objective is to measure the depolarization properties and the proximity to Lambertian (diffuse) behavior of customer-supplied and experimental target surfaces. The calibration methodology to be used will strive for maximum measurement continuity and accuracy between an integrating sphere measurement of a Lambertian primary standard, a backscatter reflectance ratio measurement of the customer's target to calibrate a lidar system. Accuracy will be achieved through careful experimental techniques such as incorporating spinning targets to reduce speckle effects. Continuity between the three measurements will include: (1) target continuity; (2) illumination continuity wavelength, polarization, and bandwidth; and (3) geometric continuity (polar angles, solid angles, and target size to beam size relationship).

W88-70157 **146-72-11**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ATMOSPHERIC BACKSCATTER EXPERIMENT
R. T. Menzies 818-354-3787
(146-72-04; 146-72-10)

The objective of this program is to support studies of the feasibility and scientific value of an Earth-orbiting Doppler lidar for global-scale tropospheric wind measurements, by the direct measurement of tropospheric aerosol backscatter coefficients at wavelengths in the 9 to 11 micron range over large geographical regions, emphasizing those regions which are important in the global winds measurement studies but difficult to characterize at present due to the scarcity of aerosol measurement data. The use of nadir directed, range-gated lidar to obtain altitude profiles of aerosol backscatter coefficients is an efficient means of sampling the troposphere at carefully selected times. This investigation will initially consist primarily of the design and fabrication of an airborne CO2 lidar, which would be mounted on the NASA DC-8 research aircraft and configured to measure vertical profiles of aerosol backscatter from the aircraft altitude (near the tropopause) to the ground. The lidar would be flown on the NASA DC-8 on at least two latitude survey missions over the Pacific Ocean, and possibly on a flight series dedicated to Southern Hemisphere measurements. The data obtained will be analyzed and considered in the context of related instrument measurements of atmospheric aerosols and other atmospheric parameters.

Upper Atmospheric Research Program

W88-70158 **147-00-00**
Langley Research Center, Hampton, Va.
UPPER ATMOSPHERIC RESEARCH
R. R. Nunamaker 804-865-2893

The objective of this RTOP is to support specific theoretical and analytical studies, laboratory investigations, and field measurements aimed at improving our knowledge of the earth's upper atmosphere and its potential for change. High-resolution laboratory spectroscopy with diode lasers and a Fourier transform spectroscopy (FTS) system will be focused on atmospheric

measurement needs with emphasis on studies of gases with complex spectra and on temperature-dependent line halfwidth measurements. Computational chemistry research will be conducted to determine photo- and thermo-chemical properties of atmospheric molecules which are difficult to study experimentally with emphasis on short lived atmospheric species. In collaboration with other atmospheric spectroscopy research programs, high-resolution infrared atmospheric spectra will undergo comprehensive analysis for determination of trace gas profiles and of data needed for remote sensing experiments. Lidar ozone and aerosol measurements and in situ ozone measurements will be obtained and analyzed as part of a 1987 Antarctic Ozone Experiment. Upon recommendations by the NASA Upper Atmospheric Research Program, research tasks at universities and other government laboratories will be supported in the areas of atmospheric measurements and infrared laboratory spectroscopy.

W88-70159 **147-11-07**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DIODE LASER
C. R. Webster 818-354-7478

The Balloon-Borne Laser In-Situ Sensor (BLISS) task has as its primary objective the collection of reliable data on the concentrations, distributions, and variabilities of the minor and trace species in the stratosphere. These data are to be used by modelers and dynamicists to assess and predict the effects of change in the chemical content of the upper atmosphere due to anthropogenic activity. The BLISS instrument uses tunable diode lasers (TDLs) to measure the absorption due to selected species between the balloon gondola and a lowered retroreflector which defines up to a 1 km absorption path. The TDL beam in use is stabilized onto the lowered retroreflector by use of an optical tracking system. Several species can be measured simultaneously to the 0.1 ppbv level in sensitivity, throughout a diurnal cycle, and with the additional possibility of altitude profiling. The current measurement capability includes NO, NO2, O3, jNO2, HNO3, H2O, CO2, and CH4.

W88-70160 **147-12-00**
Goddard Space Flight Center, Greenbelt, Md.
UPPER ATMOSPHERE RESEARCH: FIELD MEASUREMENTS
J. E. Mentall 301-286-8959

The objectives of this RTOP are to: (1) determine the specific local chemical and physical interactions in the atmosphere by a combination of theoretical studies and coordinated in-situ measurement campaigns from rocket and balloon platforms; (2) investigate the variations and perturbations of the chemical and physical state of the atmosphere, i.e., variations with altitude, solar conditions, season, latitude, and perturbations from volcanoes, tropical storms, industrial and agricultural activity; and (3) develop and calibrate selected instruments for local and remote investigations of the atmosphere. A balloon-borne Michelson interferometer will be developed to measure the concentrations and diurnal variations of trace stratospheric species. A pointed spectrometer system will be developed to measure the solar photon flux within the stratosphere. Multi-instrument, coordinated measurements will be performed on minor species in the stratosphere. Photochemical models will be developed in order to compare experimental results with theoretical predictions. As a result of this RTOP, photochemical models will be improved and validated. Understanding of upper atmosphere composition, chemistry, dynamics, and transport will be improved. In-situ solar flux and the accuracy of radiative transfer calculations will be determined. Finally, effective absorption cross-sections for O2 and O3 will be obtained.

W88-70161 **147-12-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFRARED RADIOMETRY
C. B. Farmer 818-354-2039

The objective of this task is to provide a database of stratospheric composition measurements, inferred from high resolution infrared spectra of the atmosphere, against which computer model predictions may be tested. Particular emphasis will be placed on the simultaneous measurement of those families of molecules which play a critical role in determining the amount and distribution of ozone. The approach will be to measure the spectral absorption of solar radiation by the atmosphere over the entire 2 to 16 micron spectral region using a Fourier transform spectrometer, the Mark 4 Interferometer. Measurements will be made from ground-based sites such as the Jet Propulsion Laboratory, its Table Mountain Observatory site and Antarctica, as well as stratospheric research balloons launched from Palestine, Texas.

W88-70162 **147-12-06**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MILLIMETER AND SUBMILLIMETER RADIOMETRY
J. W. Waters 818-354-3025
(673-18-49)

The objective of this program is to improve understanding of earth's upper atmosphere by balloon-based microwave measurements. Well-founded concerns that man's technological activities may perturb upper atmospheric balances, particularly those maintaining stratospheric ozone, justify this objective. The approach is to first determine which measurements are needed for atmospheric research and perform calculations to define which subset of these can be usefully performed by microwave techniques. A field program is then established for those measurements of sufficient value. The field program may involve instrument development or improvement. One important goal of this program is to determine both the capabilities and limitations of microwave techniques so they can be used efficiently in NASA's overall Upper Atmosphere Research Program.

W88-70163 **147-12-15**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FAR INFRARED BALLOON RADIOMETER FOR OH
H. M. Pickett 818-354-6861

A stratospheric hydroxyl radical (OH) radiometer for balloon observations in the far infrared region is to be developed. This instrument will use three Fabry-Perot resonators to resolve stratospheric limb emission of OH at 101/cm (99 micron wavelength). The resolution will be 0.001/cm (30 MHz) to match the stratospheric OH spectral line profile. Calculations indicate that the instrument will have sensitivity for retrieving useful OH concentration profiles between 25 km and 46 km with 3 km vertical resolution. The instrument is compact (approximately 0.1 cubic m), light-weight (approximately 30 kg), requires low power (approximately 25 W) and thus is well-suited to balloon observations.

W88-70164 **147-13-15**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DIAL SYSTEM FOR STRATOSPHERIC OZONE 3
I. S. McDermid 818-354-3213

The objective of this project is the establishment of a facility at the Jet Propulsion Laboratory (JPL) Table Mountain Observatory at Wrightwood, California, from which to make atmospheric measurements. This facility will use the laser remote sensing technique of differential absorption lidar (DIAL) to derive atmospheric ozone concentration profiles. The goal is to provide measurements with a precision of 1 percent at altitudes up to 50 km. Below 40 km the range resolution will be less than 1 km, while above 40 km range elements of 2 km and 5 km will be necessary to maintain the 1 percent precision in the concentration measurement. Two separate systems are required to obtain the full profile from the ground to 50 km. For the tropospheric part of the profile the lidar system will employ a Nd:YAG laser which, after Raman shifting, will emit wavelengths in the 285 to 295 nm region. For the stratosphere much higher laser energies are required and these will be provided by a xenon chloride excimer laser system operating fundamentally at 308 nm. A large, 36 inch diameter telescope will be used to collect the elastically backscattered laser radiation from the atmosphere, which can be analyzed to provide the ozone profile. Measurements will ultimately be obtained on every night that the atmospheric viewing conditions

permit, which is expected to be on the order of three days out of four. Long term data is required to detect the very small trends in the ozone concentration, which are masked by the large variations caused by seasonal changes, etc. It is anticipated that the JPL-TMO facility could become part of a NASA network of atmospheric monitoring stations making similar observations.

W88-70165 **147-13-17**
Goddard Space Flight Center, Greenbelt, Md.
GROUND-BASED LIDAR O3
T. J. McGee 301-286-5645

The objective of this RTOP is to monitor stratospheric ozone from the ground with a sensitivity sufficient to detect predicted trends. The approach will be to measure ozone using a differential absorption lidar. The lidar will make use of a XeCl excimer laser. Ozone profiles from 25 to 45 km will be measured on a nightly basis, weather permitting.

W88-70166 **147-14-07**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ALTITUDE TEMPERATURE PROFILES
B. L. Gary 818-354-3198

The proposed task is to provide measurements of air temperature versus altitude from the NASA ER-2 aircraft during investigations of stratospheric tropospheric exchange processes and of the Antarctic ozone hole. By knowing the temperature and lapse rate of air at nearby altitudes, and by combining this information with measurements from other in situ and remote sensor systems, it will be possible to specify properties of the air that are crucial to the above mentioned investigations. A microwave radiometer is used to measure brightness temperature at a selection of elevation angles every 14 seconds. Post-flight analysis of mean temperature and pressure (MTP) data convert brightness temperature versus applicable height to profiles of air temperature versus altitude. The Stratospheric/Tropospheric Exchange Project (STEP) flights have already occurred, and data analysis will continue under this task. The Antarctic ozone flights are scheduled for August and September 1987. The Antarctic ozone investigation involves 22 experiment teams, with approximately two dozen instruments on either the NASA ER-2 or DC-8 aircraft.

W88-70167 **147-14-12**
Ames Research Center, Moffett Field, Calif.
STRATOSPHERE-TROPOSPHERE EXCHANGE PROJECT (STEP) MANAGEMENT
P. B. Russell 415-694-5404

This RTOP has two major components, the Stratosphere-Troposphere Exchange Project (STEP), and the Airborne Antarctic Ozone Hole Project. The second component, added in FY87 in rapid response to the discovery of the hole, uses many of the instruments flown in STEP. Hence, some tasks, originally applicable only to STEP, now include an Antarctic Ozone component. The overall goal of STEP is to advance our understanding of the mechanisms that transport gases and particles between the stratosphere and troposphere and within the lower stratosphere, and to quantify the rates of exchange on local and global scales. Specific aims are to: (1) determine whether cumulus towers and their cirrus anvils are a net source or sink of stratospheric water vapor, and understand the detailed mechanism; and (2) quantify the mass exchanged across the cloud-free tropopause, and determine transfer times. Missions were flown in 1984 to 1987. The data analysis and publication period is expected to last through 1989. The goal of the Airborne Antarctic Ozone Hole Project is to explain the Antarctic springtime depletion of ozone that has developed since about 1978. The approach is to fly instruments on the ER-2 and/or DC-8 aircraft through or under the ozone-depleted regions. Instruments are chosen to supply data that can help to test the various hypotheses developed to explain the depletion. Data will be analyzed jointly and publications developed.

W88-70168 **147-15-01**
Goddard Space Flight Center, Greenbelt, Md.
UV ABSOLUTE FLUX AND VARIABILITY
J. E. Mentall 301-286-8959

The objective of this RTOP is to improve our understanding of mesospheric and stratospheric chemistry by measuring the composition and temperature of the upper atmosphere as well as the solar ultraviolet (UV) irradiance which initiates photochemical reactions. A variety of rocket borne instruments is used to measure the properties of the upper atmosphere and the incident solar irradiance. A cryogenic grab sampler obtains 4 gas samples between 75 and 30 km. Rocketsondes measure the temperature and density of the middle atmosphere. Temperature soundings are used to obtain temperature profiles. Periodic launches of UV spectrometers measure the absolute UV irradiance outside the atmosphere. Expected results include measurement of trace constituents, temperature and density of the upper atmosphere and determination of the variability of the solar irradiance over a complete solar cycle. These measurements are to be used in atmospheric models and to provide ground truth for satellite instruments.

W88-70169 **147-16-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTI-SENSOR BALLOON MEASUREMENTS
J. H. Riccio 818-354-4415
(147-12-05; 147-12-06; 147-12-08)

Continuing technical, logistical and operational support of stratospheric balloon flights is conducted to measure the abundance and altitude distribution of key chemical constituents in the upper atmosphere. Two modular gondola systems can carry multi-instrument packages consisting of several Jet Propulsion Laboratory (JPL) remote sensing instruments and instruments from other institutions in the U.S. or abroad, configured for a particular scientific purpose. Data obtained on the altitude profiles for a number of chemically coupled species from one or simultaneous flights in the same air is used for instrument intercomparison purposes and for the validation of atmospheric chemical models.

W88-70170 **147-18-00**
Wallops Flight Center, Wallops Island, Va.
ECC OZONESONDE TESTS AND DEVELOPMENT
A. L. Torres 804-824-1553

The objective of this RTOP is to determine the altitude dependence of accuracy and precision for the Electrochemical Concentration Cell (ECC) ozonesonde used by NASA for measuring vertical profiles of atmospheric ozone. An earlier study (Barnes et al., 1985) demonstrated the usefulness of laboratory flight simulation for evaluating the performance of ozonesondes. The 3A models in use at that time were found to overestimate ozone amounts up to about 10 mb, and to seriously underestimate ozone above this altitude. This RTOP supports the continued development of a successor to the earlier flight simulator, and its use in evaluating the performance of model 4A sondes currently used in ozone soundings. The flight simulator will compare ozonesonde results with those from a laboratory-grade ozone photometer with calibration traceable to the National Bureau of Standards. These tests will evaluate both absolute accuracy and precision during simulated soundings from the surface to 3 mb altitude. The development of an automated ozonesonde/radiosonde system aimed at improving precision and reducing labor costs will continue in FY88 but at a reduced pace. Currently, there are uncertainties both in the performance of the digital radiosonde that we have tested and in the radiosonde marketplace which suggest that a large-scale effort built around a particular radiosonde may not be prudent at this time.

W88-70171 **147-21-02**
Goddard Space Flight Center, Greenbelt, Md.
UPPER ATMOSPHERE: REACTION RATE AND OPTICAL MEASUREMENTS
L. J. Stief 301-286-7529

The objective of this RTOP is to measure kinetic rate

coefficients of importance to the stratosphere and mesosphere and to develop new optical techniques for detection of atmospheric species. The laboratory effort in chemical kinetics uses existing equipment of unique capability for the purpose of measuring absolute rate constants of reactions of importance in current models of the stratosphere. Rate constants of atom-molecule and radical-molecule reactions are measured as a function of temperature and pressure using the technique of flash photolysis-resonance fluorescence. Rate constants for reactions of atoms and free radicals with both free radical and molecular species are measured as a function of temperature using a recently constructed discharge flow system with collision free sampling to a mass spectrometer. Intracavity laser absorption is being developed as a complement to both fluorescence and mass spectrometric detection. Expected results include improved knowledge of chemical reaction rates at temperature and pressures appropriate to the upper atmosphere. The use of mass spectrometry for detection, monitoring, and direct analysis of reaction products adds a new dimension to our capability. This allows us to determine reaction channels and provide direct evidence for elucidation of reaction mechanisms. Application of intracavity absorption permits detection of atoms and molecules by exciting forbidden or predissociated transitions, e.g., O(sup 1 D) and ClO.

W88-70172 **147-21-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CHEMICAL KINETICS OF THE UPPER ATMOSPHERE
W. B. DeMore 818-354-2436

The purpose of this RTOP is to obtain direct measurements of rate constants and temperature dependences for reactions of HOx, NOx, ClOx, BrOx and ROx in stratospheric chemistry, and to develop techniques for laboratory study of relevant transient species.

W88-70173 **147-22-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PHOTOCHEMISTRY OF THE UPPER ATMOSPHERE
W. B. DeMore 818-354-2436

The objective is to conduct laboratory studies of stratospheric photochemistry, including photolytic quantum yields, reaction rates and mechanisms, product distributions, and absorption cross sections.

W88-70174 **147-22-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ATMOSPHERIC PHOTOCHEMISTRY
M. J. Molina 818-354-5752

Laboratory studies will be conducted to elucidate the photochemistry of atmospheric species, with particular emphasis on the Antarctic stratosphere. Measurements will include: (1) reaction rate constants involving radicals and various polar molecules over an extended pressure and temperature range; (2) absorption cross sections as a function of wavelength and temperature; (3) Fourier transform infrared (FTIR) spectra of reaction intermediates; and (4) chemical reactions involving ice particles.

W88-70175 **147-23-01**
Ames Research Center, Moffett Field, Calif.
QUANTITATIVE INFRARED SPECTROSCOPY OF MINOR CONSTITUENTS OF THE EARTH'S STRATOSPHERE
C. Chackerian, Jr. 415-694-6300

Remote detection and measurement of stratospheric minor constituent species via spectroscopic techniques is being routinely employed to develop a better understanding of this portion of our atmosphere and man's effect upon it. Proper interpretation of these measurements relies strongly on having the correct molecular parameters. The objective of this work is to obtain laboratory measurements of basic molecular parameters, such as rotational line intensities and half-widths, absorption band intensities, vibrational and rotational constants, vibration-rotation interaction constants, and line position measurements including pressure induced shifts. The determination of these parameters, and their dependence on pressure and temperature, will be obtained by using cooled long path gas cells, high resolution interferometers, and tunable diode laser spectrometers.

W88-70176 **147-23-08**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFRARED LABORATORY SPECTROSCOPY IN SUPPORT OF STRATOSPHERIC MEASUREMENTS
R. A. Toth 818-354-6860

The program involves the acquisition of laboratory spectra and the analysis of molecular spectral parameters which are required for the interpretation of data from stratospheric measurements. The laboratory spectral measurements will be conducted specifically in support of the Jet Propulsion Laboratory (JPL) infrared interferometers. These instruments have requirements relative to spectral regions of operation, spectral resolution, and molecules for which they are best suited. Emphasis is placed on accuracy of line frequency, line width, and line strength measurements in order to take full advantage of spectroscopic techniques for quantitative atmospheric species measurements. A large portion of the spectral data will also be of value to other groups who use spectroscopic instruments for atmospheric measurements.

W88-70177 **147-23-09**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LASER LABORATORY SPECTROSCOPY
C. R. Webster 818-354-7478

The laser laboratory spectroscopy program involves the acquisition and analysis of molecular spectral parameters which are required for the interpretation of data from laser stratospheric measurements, specifically by the Balloon-borne Laser In-Situ Sensor (BLISS) infrared laser instrument. Line positions, absorption strengths, and air broadening coefficients are the spectral parameters measured. New spectroscopic techniques for laser wavelength calibration and spectral lineshape analysis are also investigated.

W88-70178 **147-23-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MILLIMETER/SUBMILLIMETER LABORATORY SPECTROSCOPY
E. A. Cohen 818-354-4701

A program of laboratory studies related to stratospheric research will be conducted in millimeter and submillimeter spectroscopy. The program involves the acquisition and analysis of molecular spectral parameters which are required for the interpretation of data from stratospheric measurements. The laboratory spectral measurements will be conducted specifically in support of the Jet Propulsion Laboratory (JPL) millimeter radiometer instruments. Emphasis is placed on accuracy of line frequency, line width, and transition moment measurements, in order to take full advantage of spectroscopic techniques for quantitative atmospheric species measurements. A large portion of the spectral data will also be of value to other groups who use spectroscopic instruments for atmospheric measurements.

W88-70179 **147-51-01**
Goddard Space Flight Center, Greenbelt, Md.
ASSESSMENT OF OZONE PERTURBATIONS
R. S. Stolarski 301-286-9111

The objective of this RTOP is a continuing evaluation of the state of knowledge of the stratosphere so that reports to the Environmental Protection Agency (EPA) and Congress, as required by law, can be made consistently and accurately. The approach is the formation of evaluation teams to examine the most important current issues in the science today.

W88-70180 **147-51-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DATA SURVEY AND EVALUATION
W. B. DeMore 818-354-2436

An up-to-date tabulation and critical evaluation of kinetic and photochemical data relevant to the stratosphere will be maintained for use by atmospheric modelers, to aid in the establishment of research priorities, and to identify gaps or inconsistencies in the database.

W88-70181 **147-51-12**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTERDISCIPLINARY SCIENCE SUPPORT
M. T. Chahine 818-354-2433
(147-90-20)

The objective of this RTOP is to support the NASA Earth Sciences and Applications Division in the development and application of remote sensing techniques to study land surface processes and their interactions with the atmosphere. The science support to the NASA Earth Systems Science Program will be provided through the assistance of Professor R. Goody, Professor S. I. Rasool, Professor M. McElroy and Dr. J. Baker. Additional science support could be added subject to Jet Propulsion Laboratory (JPL) and NASA Office of Space Science and Applications (OSSA) Code EE mutual agreement.

W88-70182 **147-52-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DETAILEE/UPPER ATMOSPHERE RESEARCH PROGRAM
C. Elachi 818-354-5673

The objective of this RTOP is to provide support to the Earth Science and Applications Division, by the assignment of a Jet Propulsion Laboratory (JPL) detailee to NASA Headquarters. The primary duties of the detailee will be to coordinate present and future activities of the NASA Upper Atmosphere Research Program, and to assist in the development of an interdisciplinary Earth Science Research Program.

Interdisciplinary R&A

W88-70183 **148-13-02**
Langley Research Center, Hampton, Va.
INTERDISCIPLINARY RESEARCH: GLOBAL METHANE
R. C. Harriss 804-865-4447

This study will quantify methane emissions to the atmosphere from northern peatlands and tundra. Studies include field measurements of methane flux and laboratory/experimental studies of factors such as substrate composition, soil moisture, and soil temperature that regulate the production and release of methane to the atmosphere. Through collaboration with other programs, field and laboratory studies of CH4 efflux from peatland and wet tundra environments in Canada and northern Minnesota will be conducted. Field measurements will be made at sites where comprehensive ecological and geochemical studies are being conducted by other groups to ensure the best possible basis for global intercomparisons and extrapolations. Approximately 50 percent of the world's peatlands are located in North America which also enhances the likelihood of obtaining a globally significant data base and improved understanding of CH4 flux from northern peatlands and tundra.

W88-70184 **148-23-00**
Goddard Space Flight Center, Greenbelt, Md.
ATMOSPHERIC OPTICAL PROPERTIES OF THE SAHEL
Brent N. Holben 301-286-2975
(677-92-00)

This study is addressing the magnitude of the influence of aerosols on Global Inventory Modeling and Monitoring System (GIMMS) monitoring and modeling of green vegetation dynamics in the African Sahel using satellite data. This research will monitor the spatial and temporal aerosol content of the atmosphere and develop a tractable wetland for correcting the Advanced Very High Resolution Radiometer (AVHRR) satellite data for these measurements. Sun photometer data will be taken at up to 20 sites across 4000 km of the Sahel daily for three years. The data will be corrected to aerosol optical thickness and analyzed for spatial and temporal variability and wavelength dependence. The data will be statistically analyzed and entered into a climatological data base which will be available for making atmospheric correction over composited AVHRR images. The data will continue to be collected through FY88 and entered into the data base. The radiation transfer model is expected to be operational and the framework for making an atmospheric correction established. A preliminary evaluation of the spatial and temporal variability of the aerosols should be made. A proof-of-concept atmospheric correction will be completed.

W88-70185 **148-31-00**
Goddard Space Flight Center, Greenbelt, Md.
NORTH ATLANTIC PRODUCTIVITY: BASINWIDE STUDIES OF THE VARIABILITY AND INTERRELATIONSHIPS OF PHYSICAL AND OCEANIC BIOLOGICAL PROCESSES
W. E. Esaias 301-286-5465

The objective of this RTOP is to better understand the role of marine primary productivity in global scale carbon and other biogeochemical cycles, and the large scale mechanisms affecting the mean and variability of oceanic phytoplankton processes. This improved understanding of ocean biogenic carbon flux will be used to develop better model functions for the oceanic component of carbon on annual to climatological scales, and additionally will be useful to assess a number of second order oceanic processes in the climate and earth radiation system, such as the generation of methylene disulfide to phytoplankton, as well as serving as an important oceanographic study. The approach is to perform initial statistical analysis of recently processed Nimbus-7 Coastal Zone Color Scanner (CZCS) ocean basin pigment fields, develop methodology for estimating primary productivity using simple relationships developed within the ocean color community, and correlation of these fields with other satellite ocean and atmospheric data sets describing the physical fields and their variability.

Planetary Geology R&A

W88-70186 **151-01-20**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY GEOLOGY
William C. Phinney 713-483-5310

The broad objective of the study of planetary surface processes is to develop a coherent body of data on planetary surface processes which can be used to design planetary missions and to interpret data as well as place boundary conditions on planetary evolution. The study of appropriate analogues not only places boundary conditions on the evolution of other planets such as Mars but also permits, on earth, the evaluation of the characteristics of planetary surface instrumentation. Future exploration of Mars and other planets includes surface analysis and sample return missions. The development of these missions requires suitable instrumentation for analyses on the surface of Mars and analogues of Martian surface material. Specific objectives are: (1) to determine through detailed grain-by-grain studies of several terrestrial soils the processes and history that can be deduced through such data; (2) to characterize the gases released by thermal decomposition of Martian surface analog materials and evaluate the feasibility of accomplishing such analyses in situ; (3) to map the volcanic stratigraphy on the surface of Io; and (4) to determine the thermochemical properties and kinetics of potential regolith material on Mars and Venus.

W88-70187 **151-01-60**
Ames Research Center, Moffett Field, Calif.
SOLAR SYSTEM STUDIES
P. Cassen 415-694-5597

The purpose of this research is to address selected problems pertaining to the origin, evolution, and present state of the solar system. Theoretical concepts, physical insight, and mathematical

modeling are used together with astronomical and geological data and experiments relating to aeolian processes to construct self-consistent mathematical models of planetary processes and structures. Problem areas that are being addressed include: (1) the dynamics and evolution of the solar nebula, and protostellar disks in general; (2) the formation of planets and satellites; (3) the structure and origin of planetary rings; (4) the interaction of planetary atmospheres with surfaces; and (5) the existence and nature of extra-solar system planets.

W88-70188 **151-01-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETOLOGY
D. B. Nash 818-354-4154

This large group of interrelated tasks at the Jet Propulsion Laboratory (JPL) addresses the geology and geophysics of all planetary bodies including planets, satellites, the moon, asteroids and comets. Emphasis is on solid body aspects of these solar system objects including studies of their surface composition and structure, interior structure and thermal states, those atmospheric and magnetospheric aspects which relate to surface and interior properties, their orbital and interior dynamical properties, and their overall histories and modes of origin. The basic objective of this research plan is to determine from observational data, laboratory experiments, and theoretical considerations the present characteristics and past histories of planetary bodies both as individuals and groups, and what comparative studies of all planetary objects tell us about the history and origin of the solar system. Another major objective is to carry out interpretive analysis of observational results obtained by unmanned spacecraft missions and groundbased telescopic observations of objects throughout the solar system, and to derive new missions and new observations to further our knowledge of the solar system. This RTOP supports various laboratory experimental facilities, image processing capabilities, and the NASA Regional Planetary Image Facility at JPL.

W88-70189 **151-02-50**
Goddard Space Flight Center, Greenbelt, Md.
MARS GEOLOGY: CRUSTAL DICHOTOMY AND CRUSTAL EVOLUTION
Herbert Frey 301-286-5450

The objectives of this RTOP are to: (1) understand the nature, origin and development of the fundamental crustal dichotomy on Mars and its relation to the overall geologic evolution of the planet; (2) determine the nature, origin and evolutionary history of the transition zone which separates the cratered highlands from the northern plains; and (3) determine to what extent the lowland plains contain relics of ancient highland material. Photogeologic mapping of features characteristic of the highland boundary transition zone is used to define morphological terrain units, within which impact craters are counted. Cumulative frequency curves are used to determine the number and crater ages of resurfacing events; crater diameter ranges which define these events are used to constrain the nature of the resurfacing process. Correlation of major resurfacing events with other geologic events on Mars is made. Characterization of the transition zone in terms of its evolution is done. Relics of old highland crust are sought and their distribution mapped. Where possible crater counts are used to constrain the ages.

W88-70190 **151-02-51**
Goddard Space Flight Center, Greenbelt, Md.
GEOCHEMISTRY OF VENUS AND REMOTE SENSING OF IMPACT CRATERS
James B. Garvin 301-286-6565

This investigation seeks to explore chemical analogues to the observed surface composition of the surface of Venus in an effort to better understand the petrogenetic pathways affecting magmas on Venus. A second component of this project focuses on multispectral imaging of terrestrial impact craters in an effort to determine the spectral signatures of impact-related rocks distributed around well-exposed impact structures, and to test the hypothesis that such information can be used to evaluate whether suspected impact features are in fact of impact origin. The main objective of the second part of this study is to establish the basis from which Visible and Infrared Mapping Spectrometer (VIMS) data from Mars Observer can be used to map impactites around Martian craters in the early 1990s. Statistical searches of large terrestrial databases of rock composition data, such as IGBA, will be undertaken for the best matches to the Venus compositions from Venera and Vega X-Ray Fluorescent Spectrometer (XRFS) and Gamma-Ray Spectrometer (GRS) and melting experiments on the best analogues, especially if basaltic, will be pursued. Electrical properties of Venus analogue Earth rocks will also be determined and compared with Venera/Vega data. Sulfur will be determined for a few of the Venus analogues as well. For the impact cratering study, LANDSAT Thematic Mapper (TM), Speed Position and Track (SPOT), Airborne Visible and Infrared Imaging Spectrometer (AVIRIS), and other multispectral imaging datasets will be acquired and analyzed for a select few known impact features such as Meteor, Goat Paddock, Elgygytgyn, Zhamanshim, Ries, and Haughton. The spectral signatures of known impactites will be determined from these data. Two suspected impact features, Al Madafi and Aorounga, will be explored for similar spectral patterns to confirm or refute their origin.

W88-70191 **151-20-80**
Ames Research Center, Moffett Field, Calif.
MARS EXOBIOLOGY RESEARCH CONSORTIUM
G. C. Carle 415-694-5765
(199-52-52)

The objective of this research is to develop a better understanding of the Martian surface geochemistry and its overall relationship to volatile distributions, sources, sinks, and cycles from the exobiologist's perspective.

Planetary Materials

W88-70192 **152-11-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: MINERALOGY AND PETROLOGY
I. Dale Browne 713-483-5132

The general objective is to obtain information about the nature, origin and evolution of the solar system. The specific objective is to learn the pressure, temperature and chemical composition of distinct mineralogic phases at the time of their formation. Textures, structures and chemical composition of minerals found in samples of the moon, meteorites (asteroids, comets, Mars), cosmic dust (comets, asteroids) and the earth will be measured using optical and electron microscope and electron microprobe techniques. Comparison of these results with those from laboratory calibration experiments and theoretical models will lead to pressure, temperature and history information for parts of solar system objects.

W88-70193 **152-12-40**
Goddard Space Flight Center, Greenbelt, Md.
A LABORATORY INVESTIGATION OF THE FORMATION, PROPERTIES AND EVOLUTION OF PRESOLAR GRAINS
J. Nuth 301-286-9467
(188-41-51; 154-75-80)

The objectives of this program are to: (1) perform experiments to determine the mechanism by which refractory materials condense from the vapor and the relative importance of the factors which control the rate of cluster formation and growth for astrophysically relevant species; (2) determine the structure and composition of solids condensed from cosmically abundant refractory mixtures; and (3) monitor changes which occur in the materials as the result of thermal annealing, hydration, and exposure to cosmic rays. The results will be a major contribution to characterizing the nature of grains present in the primitive solar nebula prior to its collapse. Objective 1 will be investigated using a cluster beam apparatus. The equilibrium composition and size

distribution of clusters as a function of temperature will be monitored via a quadrupole mass spectrometer. This data will yield the concentration and stability of pre-condensation clusters as a function of composition. Objectives 2 and 3 require a separate flow system, designed to produce grains rather than clusters and able to produce large amounts of multicomponent grains. The structure and composition of the initial grains will be determined via X-ray and electron diffraction and energy dispersive studies. The infrared and UV/visible spectra of these materials will be obtained and the particle morphology will be studied via scanning electron microscopy (SEM) and scanning transmission electron microscopy (STEM). Samples of these materials will be annealed at controlled temperatures for various times either in vacuo or exposed to either liquid or gaseous water or a 1 MeV proton beam and the changes thus induced studied by the above techniques.

W88-70194 **152-12-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: EXPERIMENTAL PETROLOGY
I. Dale Browne 713-483-5132

The general objective is to obtain information about the nature, origin and evolution of the solar system. The specific objective is to execute laboratory experiments and develop theoretical models which aid our understanding of the crystallization behavior of rock forming minerals. Mineral systems similar to those found in samples from the moon, meteorites (asteroids, comets, Mars), cosmic dust (comets, asteroids) and the earth will be studied experimentally by observing the products of crystallization from experimental charges of known composition cooled under known pressure and temperature conditions. Comparison of these results with the mineralogy of naturally occurring samples will lead to pressure-temperature and history information for parts of these solar system objects.

W88-70195 **152-13-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: CHEMISTRY
I. Dale Browne 713-483-5132

The general objective is to obtain information about the nature, origin and evolution of the solar system. The specific objective is to measure the concentration of selected chemical elements (major, minor, and trace) in rock samples of interest. Data obtained supplement, and are often combined with, petrologic studies to yield bounds on thermodynamic parameters at the time of rock origin. Rock samples from the moon, meteorites (asteroids, comets), cosmic dust (comets, asteroids, Mars) and the earth will be analyzed using a variety of sophisticated techniques, including neutron activation analysis (NAA), X-ray fluorescence, atomic absorption spectrophotometry, gamma-ray spectrometry, and proton-induced X-ray emission. Relative abundances of trace elements in different samples places bounds on the characteristics of the sources from which the rock-forming materials are derived.

W88-70196 **152-13-60**
Ames Research Center, Moffett Field, Calif.
PLANETARY MATERIALS: CARBONACIOUS METEORITES
S. Chang 415-694-5733

The objective of this research is to understand the processes involved in the origin and early evolution of solid bodies in the solar system through the study of meteorites. The approach taken to meet this objective focuses on the chemical and mineralogical petrographic analyses of meteorites. The abundance, isotopic composition and distribution of selected elements are measured, and the occurrence and distribution of various mineral phases are determined. Systematic searches for elemental, isotopic and mineralogic-petrologic correlations between meteorites and within a meteorite will be made so as to elucidate physical-chemical relationships in the meteorite population. From these relationships will be deduced the nature of the processes that were involved in the origins, accretion and distribution of these objects and their components in the early solar system. In turn these processes are modeled by laboratory or computer experiments from which the chemical and mineralogical outcomes can be determined. Findings from meteorite analyses and model studies are then compared for self-consistency.

W88-70197 **152-14-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: GEOCHRONOLOGY
I. Dale Browne 713-483-5132

The general objective is to obtain information about the nature, origin and evolution of the solar system. The specific objective is to determine the absolute time when a particular event, such as the eruption of a volcano or the formation of a large impact crater, occurred. The concentrations of radioactive decay products and the corresponding parent isotopes will be measured in carefully selected rock samples using mass spectrometric techniques. With knowledge of the decay constant (half life) for the radioactive element, and assuming a closed chemical system, the time since system closure may be deduced. Systems currently in use are: K-Ar, Rb-Sr, Sm-Nd, Lu, Hf and U-Th-Pb. Study of extinct radioactive nuclides, such as Pu, leads to information on the interval of time between the formation of the nuclide and its incorporation into a solid.

W88-70198 **152-15-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: ISOTOPE STUDIES
I. Dale Browne 713-483-5132

The general objective is to obtain information about the nature, origin and evolution of the solar system. The specific objective is to determine the isotopic composition of selected elements in planetary materials. Isotopically distinct material, which cannot be understood as the product of known fractionation processes, may indicate the presence of pre-solar material. Light elements are studied to learn more about fractionation processes. A secondary objective is to develop an ion microprobe which will provide easier analysis and increased spatial resolution and sensitivity for isotopic composition measurements. Samples of moon rocks and meteorites will be analyzed using mass spectrometric techniques to learn isotopic compositions, mainly of noble gases, hydrogen, carbon, oxygen and nitrogen. Theoretical calculations will be made to relate the expected products of nucleosynthesis to observations of anomalous material in meteorites. A commercially purchased ion microprobe is being upgraded in the laboratory of G. J. Wasserburg, CIT.

W88-70199 **152-17-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: SURFACE AND EXPOSURE STUDIES
I. Dale Browne 713-483-5132

The general objective is to obtain information about the nature, origin and evolution of the solar system. The specific objective is to learn about the interaction between the space environment, which consists of meteorites, galactic cosmic rays, and solar particle and electromagnetic radiation. Samples of the lunar regolith offer the opportunity to find variations in the intensity of the environmental factors over geologic time. A variety of approaches will be used. The radioactivity of cosmic-ray produced nuclides will be analyzed as a function of sample depth. Surfaces will be studied using electron microscopes. Etchable heavy element ionization damage tracks will be revealed and studied. Solar wind noble gases will be analyzed mass spectrometrically Multidisciplinary studies will be done using selected samples.

W88-70200 **152-17-7(**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EXPERIMENTAL STUDIES ON METEORITES
S. R. Rajan 818-354-8094

The objectives of this RTOP can be broadly classified as relating to understanding: (1) the formation of meteorites and chondrules; (2) nebular and other processes in the early solar system; and (3) regolith processes on meteorite parent bodies The main approach involves a combination of chemical

petrographic and nuclear track techniques on several distinct components from a variety of interesting meteorites, with emphasis on carbonaceous and gas-rich meteorites as well as shergottites. Isotopic studies will be done collaboratively on certain selected samples, when needed and/or feasible.

W88-70201 **152-19-40**
Lyndon B. Johnson Space Center, Houston, Tex.
EARLY CRUSTAL GENESIS
W. C. Phinney 713-483-5310

If meaningful models are to be developed for the evolution of the solar system, then physical and chemical constraints must be developed for the processes involved in the evolution of the solid objects in the solar system. The specific objectives are: to identify the key physical and chemical processes and the initial conditions for crustal evolution, to understand the evolution of planetary crusts in relationship to the overall history of individual planetary bodies, and to understand the reasons for the differences in evolution among the various planetary crusts. The strategy is to adopt an interdisciplinary and cross-planetary approach to the questions of crustal genesis. The program is a multidisciplinary effort carried out by individual scientists and teams from universities, industries, and government agencies. Major efforts will be devoted to studying samples that are related to the early formed crusts, searching for early terrestrial crustal units, studying materials from potential terrestrial analogs of early planetary crusts, and modeling crustal evolution.

W88-70202 **152-20-01**
Goddard Space Flight Center, Greenbelt, Md.
MICROGRAVITY NUCLEATION AND PARTICLE COAGULATION EXPERIMENTS
J. Nuth 301-286-9467
(152-12-40; 188-41-51)

Laboratory studies of the vapor-solid nucleation of refractory species have been hampered by thermal convection. This problem is especially severe for refractory species such as SiO, C, Al2O3 and SiC, which are important in both astrophysics and meteoritics. Well controlled studies of particle coagulation are difficult to perform on earth since larger particles tend to settle out just as the experiments produce aggregates of macroscopic size. We will construct and test a system which will yield high quality data on the nucleation of refractory materials and also produce a cloud of well characterized particles which would be used to carry out studies of particle coagulation on a number of refractory species aboard NASA's KC-135 research aircraft. Refractory vapor will flow from a heated crucible, down a controlled temperature gradient until nucleation is detected via light scattering from the newly formed grains. Particles will be collected in flight and characterized on the ground. Size, composition, crystal structure and morphology will be determined. If the particles produced during the nucleation experiment are uniform, then the end of a nucleation experiment will constitute the beginning of a particle coagulation experiment. Changes in the particle size distribution due to aggregation will be monitored via light scattering and extinction measurements. Because of the short time available in 0 gravity (t less than 25 seconds), we expect that only nucleation experiments will be possible on the KC-135. Coagulation experiments will await the more extended timescales available during space shuttle flights.

W88-70203 **152-20-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: COLLECTION, PRESERVATION, AND DISTRIBUTION
D. P. Blanchard 713-483-5151

This RTOP provides for maintenance of the Lunar Sample Collection under secure, controlled environment conditions; for the description of samples as new materials are prepared for analysis; for the maintenance of records of the status and distribution of lunar samples; for providing lunar samples to approved investigators and for display purposes; and for technical monitoring of NASA-funded grants/contracts to Planetary Materials Investigators. The RTOP provides for similar functions for the Antarctic meteorite collection, including initial description, processing for distribution to investigators, and maintenance under controlled environment; dissemination of information on meteorite collection; and staff member participation in field collection. The RTOP provides for the collection of cosmic dust samples using high altitude aircraft; for the characterization of dust particles; for distribution to scientific investigators; and for dissemination of information. The RTOP provides for development of curatorial techniques for, and educational use of, materials from the various collections. Operation, which is undertaken by support contractor personnel, is directed by civil servant scientists and administrators. The program provides samples and information for about 65 domestic and foreign lunar sample investigator groups, over 100 meteorite investigator groups, and six to ten cosmic dust investigators.

W88-70204 **152-30-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: GENERAL OPERATIONS AND LABORATORY FACILITIES
M. B. Duke 713-483-4464

General operations support a variety of institutional and scientific support tasks at JSC that are considered essential for the conduct of research and for implementation of the Planetary Materials and Geochemistry Program. Center support services such as printing, computer, photographic, and graphics are provided to the Lunar and Planetary Institute through a procedural agreement. Inhouse support provides for co-sponsorship of conferences, laboratory costs required by visiting scientists using existing facilities, and for cost required to operate common laboratory facilities and to provide for support services from other Center elements. This plan also provides inhouse laboratory maintenance and Center Operations support for the visiting scientist programs of NASA (National Research Council, Lunar and Planetary Institute, NASA Graduate Intern, etc.). A significant addition to this RTOP is a plan for the systematic modernization of laboratory equipment and instruments. The overall plan includes funding from other benefitting NASA and other agency programs. The PMGP is asked to support about 20 percent of the modernization.

Planetary Atmospheres R&A

W88-70205 **154-10-80**
Ames Research Center, Moffett Field, Calif.
PLANETARY ATMOSPHERIC COMPOSITION, STRUCTURE, AND HISTORY
J. B. Pollack 415-694-5530

Theoretical modeling and spacecraft data interpretation are used to determine the properties and physical processes characteristic of planetary atmospheres. These properties include their temperature structure, aerosols, cloud layers, gaseous constituents, and opacity sources. Emphasis is placed on reducing and analyzing data returned from spacecraft missions, such as Pioneer Venus and Voyager or preparing for data expected from future spacecraft missions, such as Galileo. However, use is also made of relevant ground-based observations. In addition, the origin and evolution of planetary atmospheres and the outer planets are studied by constructing models that are constrained by relevant spacecraft and ground-based data.

W88-70206 **154-20-80**
Ames Research Center, Moffett Field, Calif.
DYNAMICS OF PLANETARY ATMOSPHERES
R. E. Young 415-694-5521

The dynamics of the atmospheres of Venus and Mars are being studied using multi-dimensional circulation models. The coupled momentum and energy equations are solved numerically using combinations of finite difference and spectral methods. The principal goals are to compare model results with spacecraft data and attempt to understand the dynamical effects of varying planetary rotation rate, solar energy deposition, infrared opacity, atmospheric mass and composition. In addition to the modeling

studies, participation in the French/USSR Vega Mission balloon experimental studies of the Venus atmospheric structure and dynamics is continuing by Ames scientists working as part of the U.S. Science Team for this mission. This work includes review of experimental approach, calibration review and analysis, and analysis of the mission data.

W88-70207 **154-20-80**
Goddard Inst. for Space Studies, New York, N.Y.
INVESTIGATION OF COMPARATIVE PLANETARY DYNAMICS
Michael Allison 212-678-5554

The general objective of this work is to explore the role of eddy, diabatic, and dissipative processes in controlling the structure and circulation of planetary atmospheres under a range of dynamic, thermodynamic and radiative conditions. Applications to Venus and Titan are expected to help assess the importance of both barotropic eddy and thermal tide interactions with Hadley cells in producing equatorial superrotation. Applications to the Jovian planets will be designed to explore the effects of moist and ortho-para convective processes in very weakly stratified, rapidly rotating atmospheres. The approach will involve: (1) analytic diagnostic studies of the equations of atmospheric motion simplified by scalings appropriate for fast and slow rotation, strong and very weak stratification and linearized parameteorizations for diabatic forcing and dissipation; (2) experiments with a simplified version of the Goddard Institute for Space Science (GISS) general circulation model to simulate the fully non-linear and three-dimensional dynamics for a range of forcing and dissipation settings suggested by the diagnostic analysis; and (3) development of parametric models for the general circulation of atmospheres based on the results of the general circulation experiments for comparison with planetary observations.

W88-70208 **154-30-80**
Ames Research Center, Moffett Field, Calif.
PLANETARY CLOUDS PARTICULATES AND ICES
O. B. Toon 415-694-5971

Goals of this program are: (1) to determine the physical and chemical processes responsible for the cloud structures observed on Mars, Titan, the outer planets and Venus; (2) to better define the cloud structure on Titan by reanalyzing Voyager data; (3) to provide comparisons between terrestrial and planetary clouds; and (4) to use computer models to provide a self-consistent framework for determining cloud properties from first principles of physics and chemistry. A generalized planetary cloud computer code has been developed which now allows us to approach a large number of problems from a consistent framework. The model has been used to simulate the haze on Titan, and is being readied to investigate the polar hoods and water ice fogs of Mars.

W88-70209 **154-40-80**
Goddard Inst. for Space Studies, New York, N.Y.
RADIATIVE TRANSFER IN PLANETARY ATMOSPHERES
Larry Travis 212-678-5599

The general objectives are to develop and apply techniques for extracting information on planetary atmospheres from remote sensing of scattered and emitted radiation, and to investigate the interactions and feedbacks between radiative, cloud and dynamical processes in planetary atmospheres. Applications to Venus and Jupiter in progress are expected to yield general information on cloud structure and aerosol microphysics as well as the role of clouds on radiation budget and convective processes. Information on these interactions has relevance for other atmospheres including climate processes for the Earth. Principal elements in the approach are analysis of available spectral and polarimetric data for Venus and Jupiter to obtain information on atmospheric structure, and radiative-convective and general circulation modeling to investigate interactions between clouds, radiation, and dynamics.

W88-70210 **154-50-80**
Goddard Space Flight Center, Greenbelt, Md.
ATOMIC AND MOLECULAR PROPERTIES OF PLANETARY ATMOSPHERIC CONSTITUENTS
Donald E. Jennings 301-286-7701
(196-41-54; 147-12-02; 188-41-55)

The principal goal of this laboratory spectroscopy program is to develop an organized body of knowledge of the molecular properties of planetary and cometary constituents. In the case of lower resolution planetary observations, such as Voyager Infrared Interferometer Spectrometer (IRIS) (4/cm), identifications and abundance determinations require laboratory spectra of similar resolution which can be directly compared with the observations. Condensed phases of some molecular constituents may also contribute to the Voyager spectra. The highest possible spectral resolution is required when single features apparent in medium or high resolution Fourier transform spectra (FTS) are composed of more than one molecular transition, and the parameters frequency, strength, lower state energy, and foreign-broadening must be known for each as input in modeling the atmosphere. For high resolution FTS and heterodyne observations the need for ultra-high resolution laboratory data is especially critical, since the bandwidths accessible to these receivers are narrow and Doppler line profiles are completely resolved in the observed spectra. A combination of tunable diode laser (TDL), FTS, and grating laboratory spectra can supply a complete set of line and band parameters anywhere in the infrared. In this program TDL and FTS spectrometers will be applied to selected vibration-rotation bands of planetary molecular species. Tasks include: (1) improvement of outer planet abundances using available lab data; (2) measurement temperature-dependent N2 and H2 broadening of C2H6; (3) measurement of temperature-dependent broadening and strengths in C3H8 and C2H4; (4) continuing analysis of methylacetylene near 15 microns; and (5) complete analysis of 14 micron bands of C2H2.

W88-70211 **154-60-80**
Goddard Space Flight Center, Greenbelt, Md.
PLANETARY AERONOMY: THEORY AND ANALYSIS
R. E. Hartle 301-286-8234

The basic objective is to study the observed properties of the neutral atmospheres and ionospheres of the planets and their satellites in order to identify and interpret the physical and chemical processes governing their behavior, including solar planetary relationships. One of the motivating philosophies is that the study of processes occurring in the atmospheres and ionospheres of the planets and their satellites provides important insights into the nature of similar processes operative at other planets and satellites (including Earth) but under different parametric conditions and vice versa. The investigations are pursued by analyzing and interpreting experimental data derived largely from flight programs after funding from project offices has terminated. The data is used to determine the various chemical, compositional, dynamical and energetic states of the respective atmospheres and ionospheres, including the transport and deposition of mass, momentum and energy in these regimes. In general, the approach involves the development of empirical descriptions of either global or small scale phenomena using data sets from a variety of spacecraft. These empirical descriptions of the atmospheres and ionospheres are subsequently interpreted using theoretical models developed to deduce the physical and chemical processes involved. Some of the specific phenomena addressed in this investigation include: atmospheric and ionospheric motions on Venus, Jupiter and Earth; and interactions of solar wind and/or magnetosphere with atmospheres of Venus, Titan, moons of Uranus and Earth, including modification of transport coefficients by instability processes, solar planetary relationships, comparative planetary atmospheres, etc.

W88-70212 **154-60-80**
Ames Research Center, Moffett Field, Calif.
MULTI-DIMENSIONAL MODEL STUDIES OF THE MARS IONOSPHERE
R. C. Whitten 415-694-5498
(889-50-48)

The objective of this research is to arrive at realistic predictions of ion densities, flow velocities and temperatures over the day and night sides of the Mars ionosphere in order to establish ranges and properties for use in a future Mars Aeronomy Mission. For this purpose, simple spectral models of ion density and plasma heat transport have been developed and the more complete finite difference ionospheric model for Venus is being adapted to Mars. Simple calculations have shown that the Coriolis force can be neglected to first order; hence two-dimensional (2-D) models (mainly spectra) of ion density, flow velocity, and temperatures are justified and have been or are being constructed. Preliminary results have been obtained with the aid of 2-D spectral models of ion/electron density and temperature. The results show that the plasma flux from dayside to the nightside is much smaller than on Venus. The smaller plasma flux on Mars is attributed to smaller bulk velocities and a lower ionopause height. Similar considerations hold for the transport of heat from the dayside to the nightside ionosphere. A more complete (with respect to ion chemistry) finite difference model, based on a model for Venus, is nearing completion. Extension of the 2-D spectral model to three dimensions in order to include the Coriolis acceleration has been started and will be completed in FY88.

W88-70213 **154-75-80**
Goddard Space Flight Center, Greenbelt, Md.
COSMIC CHEMISTRY: AERONOMY, COMETS, GRAINS
B. Donn 301-286-6859
(188-41-55; 152-12-40; 147-21-02)

This RTOP studies physiochemical phenomena in planetary atmospheres, comets, and related aspects of interstellar matter. Laser , spectroscopy, photochemistry, reaction kinetics, condensation processes, and vaporization and irradiation of mixtures of frozen gases are investigated and properties of atoms, radicals, molecules, ice mixtures, and grains are measured. These experimental results are used to interpret astronomical observations and develop theoretical models. Flash photolysis-resonance fluorescence apparatus with computer interface for real time analysis yield absolute atom-molecule rate constants. A continuous wave (CW) tunable dye laser is used for radical detections. Mass spectrometry has been added to discharge flow photodissociation studies of planetary or cometary radicals. A tunable dye laser is used to detect and study the properties of these radicals. Gas phase and matrix isolation condensation are used to simulate production of primordial solar system, cometary or interstellar grains and study mechanism of production. Ice mixtures are irradiated with MeV protons and ultraviolet light and the spectra and vaporization of initial and irradiation films measured. Formation and properties of porous, low density ice/dust aggregates representing components for the cometary nucleus are studied.

W88-70214 **154-80-80**
Goddard Space Flight Center, Greenbelt, Md.
SOLAR PLANETARY INTERACTION
H. A. Taylor, Jr. 301-286-6610

The objective of this RTOP is to make comparative analysis of solar-planetary interactions with environments of Venus and Earth. Emphasis is on investigating energetic disturbances resulting from differences in draping of interplanetary magnetic field about the planets. Studies of auroral-like field and particle effects at Venus will be related to understanding of similar processes at Earth. Special attention will be given to improving understanding of consequences of field draping for field aligned superthermal particle fluxes and the possible consequences of these particles for affecting the aeronomy of the lower ionosphere and for confusing attempts to make remote detection of lightning induced plasma waves. Research will include statistical analysis of quantities of high-resolution data from the Pioneer Venus Orbiter, concurrent with advanced development of theoretical models of the solar wind coupling with the ionosphere.

W88-70215 **154-90-01**
Goddard Inst. for Space Studies, New York, N.Y.
ATMOSPHERIC STRUCTURE OF URANUS: A VOYAGER URANUS DATA ANALYSIS PROGRAM CORRELATIVE STUDY
Barbara Carlson 212-678-5572

The objective of this RTOP is to analyze the spatially resolved Voyager Imaging and IRIS data in combination with a time series of ground-based observations. Multiple scattering calculations will be performed using the doubling-adding approach combined with the correlated k-distribution method to calculate the gaseous absorption associated with methane and hydrogen in the vertically inhomogeneous atmospheres. The first step will be the development of a base line vertical structure model based on the analysis of the whole disk ground-based observations obtained in 1986 (pre-Voyager encounter). Radiative transfer calculations will be used to generate synthetic geometric albedo spectra for comparison with the observations and to calculate I/F values for comparison with the Voyager measurements. Through this comparison, we hope to gain new insights into the nature of the observed temporal and spatial variation in the atmosphere of Uranus. These variations will be interpreted in terms of changes with time and location in the cloud structure model parameters, such as haze/cloud height, optical depth and particle size.

W88-70216 **154-90-02**
Goddard Inst. for Space Studies, New York, N.Y.
INVESTIGATION OF THE TEMPORAL AND SPATIAL VARIABILITY OBSERVED IN THE JOVIAN ATMOSPHERE
Barbara Carlson 212-678-5572

The objective of this RTOP is to develop a cloud retrieval algorithm with which to characterize the observed temporal and logitudinal variations in the Jovian atmosphere in terms of changes in the cloud structure model parameters such as haze/cloud height, optical depth and aerosol (haze and cloud particle) optical properties. Our radiative transfer model will use the doubling-adding approach for multiple scattering. The scattering calculations will include Rayleigh scattering, absorption by gaseous methane, ammonia and hydrogen, and scattering and absorption by the aerosols. The correlated k-distribution method will be employed to model the gaseous absorption throughout the vertically inhomogeneous Jovian atmosphere. The model will be used to calculate I/F values for comparison to observations. Our approach will yield a better understanding of the temporal variations that are apparent in a time series of ground-based spectrophotometric observations of Jupiter which resolve the planetary scale belt-zone structure and the longitudinal variations that are apparent in a sequence of high spatial (synoptic scale) and spectral resolution photometric and polarimetric charge coupled device (CCD) images.

W88-70217 **154-90-80**
Marshall Space Flight Center, Huntsville, Ala.
PLANETARY MAGNETOSPHERIC COUPLING
J. H. Waite, Jr. 205-544-7635

The objective of this RTOP is an adequate understanding of thermospheric and ionospheric processes in the Jovian, Saturnian, and Uranian planetary systems. This research involves modeling of aeronomical processes in the upper atmospheres of Jupiter, Saturn, and Uranus and the comparison of these results with the existing data from the Voyager program and ultraviolet spectrometer observations using the International Ultraviolet Explorer (IUE) telescope. The proposed modeling tasks include: (1) the modeling of energetic $O(+q)$ and $S(+q)$ ion auroral precipitation processes including energy dissipation, ionization, and emission production rates, and the first-order aeronomical consequences of ion auroral precipitation; (2) development of a follow-up time-dependent model of the Jovian upper atmosphere studying the chemical effects of oxygen precipitation once it is slowed and thermalized in the upper atmosphere; (3) modification of the Jovian time-dependent upper atmosphere model to study the effect of H_2O precipitation from

the rings of Saturn on the structure and composition of the ionosphere and upper atmosphere of Saturn; (4) interpretation of the Voyager/Uranus Ultraviolet Spectrometer (UVS) UVS and Radio Science results; and (5) study of the electroglow problem in the upper atmospheres of Jupiter, Saturn, and Uranus.

W88-70218 **154-90-80**
Ames Research Center, Moffett Field, Calif.
PLANETARY LIGHTNING AND ANALYSIS OF VOYAGER OBSERVATIONS
W. J. Borucki 415-694-6492

The general objectives of this research are to determine the role of atmospheric electrical processes in the evolution of planetary atmospheres and to delineate the electrical and meteorological processes that give rise to the extreme electric fields required for lightning. The general approach is to use comparative planetology, i.e., to compare the spacecraft observations with terrestrial observations and theory in order to understand the processes occurring on other planets and to check the applicability of the theories that have been developed to explain terrestrial lightning and atmospheric electricity. Efforts will be directed toward determining the location of the lightning activity on Venus and Jupiter and toward determining the roles of condensible vapors and air-mass convergence. The electrical charging of aerosols and droplets will also be considered.

W88-70219 **154-95-80**
Ames Research Center, Moffett Field, Calif.
PHYSICAL AND DYNAMICAL MODELS OF THE CLIMATE ON MARS
R. Haberle 415-694-6343

The climate of Mars is characterized by the seasonal cycles of dust, water and carbon dioxide. While the Mariner 9 and Viking spacecraft missions have provided a good first order definition of the amplitude and phase of these cycles, the processes controlling them remain uncertain. The objective of this work is to further the understanding of the processes controlling these cycles. The approach is to numerically simulate various aspects of these cycles using one-, two-, and three-dimensional climate models. The one-dimensional model is a time-marching boundary layer type model that includes the solar and infrared radiative effects of dust as well as carbon dioxide. It is used to isolate the effects of dust on temperature structure and feedback mechanism between dust loading and dust raising. The two-dimensional model is a zonally symmetric primitive-equation model with a tracer transport capability. It is used to study the role of atmospheric transport on the water cycle, and the radiative-dynamical feedback effects of dust on the general circulation. The three-dimensional model is used to study the effects of large-scale motions on the transport of water.

Mars Data Analysis

W88-70220 **155-20-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY DATA SYSTEM AND COORDINATION
J. T. Renfrow 818-354-6347
(656-80-01)

The objectives are to: (1) develop and implement an operational Planetary Data System (PDS) to restore planetary science data sets for inclusion in the PDS; (2) to develop the required ancillary navigation data support capabilities needed for effective utilization of the planetary science data sets; and (3) to provide coordination among all producers of planetary science data at the Jet Propulsion Laboratory (JPL). JPL will continue to develop the operational PDS in conjunction with the Integrated Science Testbed Nodes that have been started and continue to be funded by the Information System Office of Code E. The technologies identified and evaluated under this allied task are being incorporated into the operational PDS. All the system engineering and system implementation activities of both the Integrated Science Testbed Nodes and the operational PDS will be conducted under this RTOP in order to have effectively coordinated development. The process of selecting Discipline and Data Nodes for the operational PDS will be developed and the members of the planetary science community will be given the opportunity to propose to become Discipline and Data Nodes. The functional capabilities necessary to provide ancillary navigation information and data to support the planetary data will be developed so as to interface directly with the operational PDS. A Data System Coordinator will continue to serve as an interface between the planetary science community and the planetary data system developments at JPL.

W88-70221 **155-50-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MARS DATA ANALYSIS
M. P. Golombek 818-354-3883

The goals of the work under this program are to analyze a variety of data sets available for the planet Mars in an effort to put constraints on the timing, characteristics, and evolution of volcanic and tectonic processes. The primary data source for these investigations are the Viking images, which will be used to identify and characterize volcanic products and tectonic events of interest on Mars. The tectonic research focuses on unraveling the detailed structural history of extensional faulting around the Tharsis province. This approach provides a means of inferring the thermo-mechanical state and evolution of the Martian interior that is based on the geologic and structural evolution as well as the gravity and topography. The volcanic research uses dimensional and morphologic data on lava flows to develop constraints and inferences on magma sources. This work uses physical models of flow emplacement to estimate the vent and sub-surface conditions at the time of eruption and the composition of the flows. Results provide new constraints on the compositional evolution of the magma source.

W88-70222 **155-50-80**
Goddard Space Flight Center, Greenbelt, Md.
MEVTV: EARLY MARTIAN TECTONICS AND SMALL VOLCANOES
Herbert Frey 301-286-5450

The objectives of this RTOP are to: (1) understand the origin of the crustal dichotomy on Mars and its relation to the overal geologic evolution of the planet; (2) describe the global scale evolution of the transition zone between the cratered highlands and northern lowland plains in terms of major erosional processes (3) investigate the structural development of the Valles Marineris and related other canyons to constrain the pre-Tharsis lithospheric stress on Mars; and (4) classify probable Martian volcanic landforms and compare with terrestrial classification. The approach will be to search for evidence of a Borealis Basin in terms of radial and/or concentric structures through scaling comparisons with the Hellas impact basin. Evidence will be sought of a missing rim in western Mars. Individual morphological terrain units in transition zone regions in Mareotis-Tempe and in Elysium-Amazonis will be defined. Cumulative frequency curves will be determined and analyzed in terms of Neukum-Hiller resurfacing events. The age of these events will be correlated with other major geologic events on Mars. A structural map will be prepared of the Valles Marineris and related canyons (Echus, Juventae). Fault distribution, regions of likely fault interaction and fault propagation will be determined. Linear elastic fracture mechanics will be used to determine stress orientation and magnitude, fault propagation forces and contributions to lateral growth of the Valles Marineris from Tharsis tectonism. A classification scheme for Martian landforms of likely volcanic origin will be developed and distribution maps of each landform will be prepared.

Halleys Comet Watch/Experiments

W88-70223 **156-02-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTERNATIONAL HALLEY WATCH
R. L. Newburn, Jr. 818-354-2319

The International Halley Watch (IHW) has been designed to maximize the scientific value of ground-based observations of Halley's Comet. Important in their own right, such observations have also enhanced the value of space observations, setting the brief duration flyby data in the context of the overall apparition, placing the extremely high resolution encounter data into the normal scale of observations, and filling in missing data. The IHW has standardized observing techniques wherever useful and possible, coordinated the observing, and is now collecting data for publication in a comprehensive Halley Archive. The IHW has been designed to avoid the problems of 1910 where the two major monographs on Halley were not published until 21 and 24 years later and where much data remains unpublished to this day. The Giacobini-Zinner (G-Z) Watch provided support to the International Cometary Explorer (ICE) mission and complements the IHW by using the same ground-based techniques at the same time to study another very different comet for comparison. Individual nets of observers worldwide have been organized for each observing technique by eight discipline specialist teams. Overall IHW coordination internally and with flight projects is the responsibility of a Lead Center Organization (LCO) established in Pasadena, California, USA and Bamberg, Fed. Republic of Germany, as is responsibility for IHW publications. Advice and oversight protection are supplied by a 29-member Steering Group. Each flight project interfaces formally with the IHW through a project appointed project representative. Amateur contributions are being coordinated by the LCO, working through recorders (amateur comet specialists) and existing amateur organizations. The Giacobini-Zinner Watch has utilized the full, existing IHW apparatus, manpower, communications, etc. Additional funds have been used only to process actual G-Z data.

W88-70224 **156-02-02**
Goddard Space Flight Center, Greenbelt, Md.
THE LARGE-SCALE PHENOMENA PROGRAM OF THE INTERNATIONAL HALLEY WATCH (IHW)
Malcolm B. Niedner, Jr. 301-286-5821

The major objectives of this program are: (1) to construct a worldwide network of observatories with wide-field imaging capability for participation in the Large-Scale Phenomena Network of the International Halley Watch (IHW); (2) to standardize and archive the image data for submission to the permanent Halley Archive at the Jet Propulsion Laboratory (JPL); and (3) to provide support to the deep space comet Halley missions flown by international space agencies. When it is acceptable to the network observers and can be performed without additional cost, a fourth goal is to scientifically analyze network imagery using sophisticated state-of-the-art computer image processing techniques. The IHW is an organization whose steering group is composed of members from many countries and whose purpose and function, the advocacy of worldwide observations of Halley's Comet and the collection and archiving of any data so obtained, has been officially endorsed by the International Astronomical Union (IAU). The present investigator (M. B. Niedner) has been selected as a Discipline Specialist (DS) for the Large-Scale Phenomena program of the IHW. He and his team administer the NASA Goddard Space Flight Center (GSFC) portion of this program via the construction of a worldwide network for the observation of large-scale phenomena such as rapidly variable plasma-tail features and similarly wide-field dust-tail structures. The program's modus operandi involves the forwarding by participating observatories of their best photographic plates (or film copies) to the DS Team for archiving (and analysis when appropriate). Individual observatories always retain full proprietary rights to the analysis of their own data.

W88-70225 **156-03-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GIOTTO: ION MASS SPECTROMETER, CO-INVESTIGATOR SUPPORT
M. Neugebauer 818-354-2005

During the encounter of the Giotto spacecraft with Halley's comet, the NASA-sponsored High Energy Range Spectrometer (HERS) sensor of the Ion Mass Spectrometer (IMS) obtained unique information concerning the chemical composition of cometary gases and the plasma interactions of comets with the solar wind. HERS found anomalously large amounts of C(+) ions, and the data suggests that N(+) is low in abundance. The dynamical interaction of the cometary ions with the solar wind and cometary neutrals resulted in such features as a heavy ion mantle, a drop-out region closer to the comet, a bow shock with complex internal structure, a contact surface separating solar wind and cometary plasmas, and nonequilibrium plasma distribution functions. Experimental results will be used for further understanding of the origin of comets, the chemical processes that determine the composition of the cometary plasma, and the plasma dynamical, magnetohydrodynamic (MHD), and neutral interaction processes that determine the velocities and distributions of the ions. Quantitative analysis of the mass spectra, use of the measured flow field as input to chemical models, and comparison of observations with chemical models are planned. Bow shock data will be correlated with results of other experiments, theoretical modeling will determine expected pick-up distributions, and comparison of these models to observations will characterize pitch-angle scattering and thermalization. Interactions by collision and charge exchange with the neutrals will be investigated. The temporal/spatial structure of the ions should provide evidence concerning the Kelvin-Helmholtz instability, MHD wave instabilities, flux ropes, rays, etc., if present. Software for data reduction, analysis, and modeling will be refined for these purposes; and continued analysis of calibration data is planned.

W88-70226 **156-03-04**
Lyndon B. Johnson Space Center, Houston, Tex.
GIOTTO-COMET HALLEY FLYBY
Herbert A. Zook 713-483-5058

Both the average chemistry of detected particles and the size distribution of particles was found to depend on the position of the Giotto spacecraft along its Halley fly-by trajectory. The objective of the proposed research is to derive a valid understanding of the observed dependence. The approach is a two-step one. The first step is to model and establish the exact rotation dynamics of the nucleus of Halley's comet. This is required in order to understand the time history of the pointing directions of plumes of material leaving the nucleus. None of the solutions so far proposed give a good match to the telescopically observed time variations of integrated coma brightnesses. The modeling procedure will be to establish one or two (or three) active regions on the surface, numerically rotate this model comet about two or three rotation axes, and obtain estimated outgassing rates versus time. The location of the sun relative to the hypothetical rotation axis will be varied until a good fit is found. Once the nuclear rotation is established, the second step will be to model the trajectories of particles of different area-to-mass ratios in the plumes. Radiation pressure differences on the particles will also be modeled and the results will finally be compared with the actual Giotto flyby observations.

W88-70227 **156-03-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GIOTTO PIA CO-INVESTIGATOR SUPPORT
Z. Sekanina 818-354-7589

The flight data from the Giotto Particulate Impact Analyzer (PIA) experiment provide an extensive data base for studying the chemistry, mineralogy, and other properties of microscopic dust particles emitted from Comet Halley. Work of the four U.S. co-investigators under this RTOP task (Brownlee, Clark, Sekanina, Utterback) will address the following objectives: (1) study of effects of particle-collisional ionization and dissociation (including multiple

ionization), surface desorption-type reactions, and recombination processes on the mass spectra, identification of atomic/molecular equivalents to the individual peaks in the spectra, and determination of the ionization efficiencies of the various species to derive their relative abundances; (2) elemental analysis and interpretation of the results in terms of the chemical, isotopic, and mineralogical composition of the dust particles, determination of particle masses, and estimation of particle bulk densities; (3) classification of particles by their composition and relative abundances into major groups and subgroups, and comparison with potentially relevant compositional analogs of extraterrestrial origin such as interplanetary particles, interstellar grains, and meteorites; (4) study of particle structure, optical and dynamical properties, and possible fragmentation, relationships between structure and composition, comparison between the PIA results and those from the Dust Impact Detection System (DIDSY) experiment and from ground-based observations in terms of the particle-mass distribution and dust-flux profile along the spacecraft's trajectory, and possible compositional variations over the nucleus surface; and (5) overall characterization of the properties of Halley's dust-particle population and conclusions on the origin and evolution of Halley and comets in general, based on the experiment's results.

W88-70228 **156-03-05**
Goddard Space Flight Center, Greenbelt, Md.
GIOTTO: MAGNETIC FIELD EXPERIMENTS
Mario H. Acuna 301-286-7258

We have participated in the magnetometer experiment for the Giotto mission to Comet Halley. This experiment has provided rapid (up to 30 vectors/sec), precise (0.1 percent), accurate and very sensitive (+ or - 0.004 nT) vector measurements over a wide dynamic range (seven ranges from + or - 16 nT to + or - 65538 nT, with the uppermost ranges for easy check-out during S/C integration) of the magnetic fields observed during the GIOTTO encounter of Comet Halley in March 1986. Near closest approach we are most interested in the signatures in the magnetic field of dynamical processes originating near the cometary nucleus. Another major objective is the study of the interaction between Comet Halley and the solar wind at 0.8897 AU. This includes the identification of boundary surfaces such as the cometary bow shock and the transition region between a cometary magnetosheath and the cometary atmosphere closer to the comet. In addition, we shall investigate the role of the magnetic fields in the coma and magnetosheath, dynamical phenomena in the plasma interaction caused by temporal variations of the cometary gas and plasma source during the fly-by and wave phenomena generated by instabilities in the various magnetoplasma regions and regimes.

W88-70229 **156-03-07**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GIOTTO DIDSY CO-INVESTIGATOR SUPPORT
Z. Sekanina 818-354-7589

The flight data from the Giotto Dust Impact Detection System (DIDSY) experiment provide an extensive data base for studying the distribution of dust in the atmosphere of Comet Halley. Work of the two U.S. co-investigators under this RTOP task (Hanner, Sekanina) will deal with the following problems: (1) spatial density of dust as a function of the position on the spacecraft trajectory in the full range of particle masses and the total production of dust by the comet at the time of encounter; (2) particle-mass distribution function, the probable upper and lower limits on particle masses, and the particle bulk density as a function of mass, allowing conversion from the mass distribution to the size distribution function; (3) synergistic studies aimed at a global understanding of the flight data and their comparison with information from other experiments and with ground-based optical observations, including the determination of the source function of dust on the nucleus surface; (4) relationship between the mass, spatial and temporal variations derived from the DIDSY data and from infrared remote sensing data; and (5) overall interpretation of the dust-release processes and their effects on the evolution of Comet Halley.

W88-70230 **156-03-80**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PHOBOS LANDER DYNAMICS SCIENCE TEAM
R. A. Preston 818-354-6895

Range, Doppler, very long baseline interferometry (VLBI), and telemetry data from the Soviet Phobos Lander will be used to determine the dynamics of Phobos, to test relativistic gravity, and to determine the relative orientation of the extragalactic VLBI and planetary ephemeris reference frames.

Planetary Instrument Definition

W88-70231 **157-01-40**
Lyndon B. Johnson Space Center, Houston, Tex.
COSMIC DUST CAPTURE IN LOW EARTH ORBIT
Friedrich Horz 713-483-5042

Recovery of cosmic dust particles is currently limited to the stratosphere, deep-sea sediments, and polar ice caps. Because vital trajectory information is destroyed during atmospheric entry, it is not possible to assign specific astrophysical sources to these particles, such as comets or asteroids, if not interstellar regions. Reconstruction of these source areas therefore requires the combination of particle capture and trajectory measurement in low earth orbit. Inasmuch as these dust sources are among the most primitive solar system objects, valuable insight into early solar system processes related to nebula condensation and the formation of organic and inorganic compound will be gleaned; the interstellar particles may extend this information to other solar systems and associated nucleosynthetic processes. Spin-offs for the planning of diverse missions to comets and asteroids will emerge from such low earth orbit (LEO) observations and existing, terrestrial cosmic dust collections will be enhanced; the latter may be biased towards specific sources or materials. This RTOP supports the development of cosmic dust collectors, trajectory sensors and an associated user facility to be deployed during the early initial operating capability (IOC) on Space Station. A formal Memorandum of Agreement identifies the Solar System Division to have prime responsibility for such an attached Space Station payload and the Life Sciences Division to have a major, supportive role. An instrument and facility development study will be conducted by JSC over the next two years that will lead to preliminary instrument and facility designs. Existing instrument concepts will be improved via experimental and theoretical studies. Facility interfaces with Space Station will be defined and first order hardware and electronic architecture will be developed. Preliminary design will be completed by 1990 and final design is due in 1991 to have the flight hardware ready for launch in early 1994. An outline of the Project Plan, currently in draft stage, is attached. Final design must be completed by FY91 to meet an anticipated deployment of the facility during Space Station assembly flight 3 or 4 in early CY94.

W88-70232 **157-01-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED CCD CAMERA DEVELOPMENT
S. A. Collins 818-354-7393

The objective of this task is to complete the development of a large format (1024 square) charge coupled device (CCD) and to procure and archive a quantity of these devices for use in imaging systems which will be flown on future planetary spacecraft. This task is a continuation and completion of work which is currently underway. A suitable 1024 square CCD has been developed and demonstrated. During FY87 and FY88, additional units are being fabricated and archived for use in future planetary spacecraft imaging instruments. This program is expected to yield several dozen flight-quality CCDs and to provide for future availability of such devices at reasonable, reliable costs.

W88-70233 **157-03-50**
Goddard Space Flight Center, Greenbelt, Md.
X-GAMMA NEUTRON GAMMA/INSTRUMENT DEFINITION/X-RAY/GAMMA-RAY FACILITY PROGRAM
J. I. Trombka 301-286-5941

The objective of this investigation is to develop remote sensing and in situ measurement systems for geochemical and geophysical exploration of the planets, asteroids and comets. These studies will be consistent with planetary programs recommended by the Solar System Exploration Committee (SSEC). The remote sensing X-ray spectrometer study will consider proportional counters, solid-state detectors, and imaging systems. Elemental composition for elements with atomic numbers greater than Z=6 (carbon) using solar X-ray fluorescent spectral measurements are being considered. Both theoretical and experimental studies will be used in the investigative program. Both gamma-ray and X-ray detector systems are significantly affected by the space radiation environment. Both induced backgrounds and radiation damage in gamma-ray detectors, i.e., NaI(Tl), CsI(Na), Ge(Li) and Ge(High Purity), have been studied and methods for predicting the magnitude of these effects of the space radiation environment have been developed. Balloon flights of remote sensing gamma-ray and X-ray spectrometer systems will be conducted in order to ascertain their sensitivities and the magnitude of the space environment induced activity. Our group has established the feasibility of obtaining sub-surface elemental composition of a comet nucleus using a passive gamma-ray spectrometer system on a penetrometer probe. Designs of detector systems for such missions will be carried out using both theoretical and experimental methods.

W88-70234 **157-03-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MM2 IMAGING
T. H. Reilly 818-354-6078

The objective is to develop an imaging system suitable for use on the Mariner Mark 2 (MM2) spacecraft and the series of missions proposed for that spacecraft. The science objectives have been developed by the MM2 Imaging Science Team. A conceptual design has been prepared which meets most of the science requirements and the constraints of the MM2 spacecraft. The subassemblies most in need of development work were identified: charge coupled device (CCD) image detector, narrow angle optics, wide angle optics, video data compressor, square root encoder, and power supply. For the CCDs, an effort is being made to obtain these detectors from another project. The two optical systems were designed in FY86 and breadboard models are being fabricated in FY87. Detailed design of the optical mounting hardware is also underway. The FY88 effort will be directed at the video data compressor. The Galileo compressor will be used as a starting point, but many changes are required. A preliminary design will be developed, and then breadboarded on a general purpose microcomputer. A key outcome will be the determination of which compressor functions can be carried out in software, and which will require hard-wired (high speed) logic.

W88-70235 **157-03-80**
Goddard Space Flight Center, Greenbelt, Md.
LUNAR OBSERVER LASER ALTIMETER
James B. Garvin 301-286-6565

This Planetary Instrument Design and Development Program (PIDDP of Code EL) investigation intends to design and build a prototype laser altimeter instrument that would meet many of the topographic data requirements recommended for the Lunar Geoscience Orbiter. Analysis of existing lunar laser altimetry (Apollo system) and lunar topography will result in improved laser system specifications. The laser altimeter will be designed to minimize weight, power and data rate, while maintaining reliable, continuous, long-lifetime operations. Focus will be on an entirely solid-state laser transmitter involving diode-array pumping. Fast (1 to 3 nsec) Si avalanche photodiode (APD) detectors and waveform digitizers will be integrated with the diode-pumped redundant Nd:YAG lasers in a simple design. An Al telescope mirror will form the heart of the receiver. A single channel spectrometer made (at 810 nm or 1.06 micrometers) will be explored.

W88-70236 **157-04-80**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DIODE LASER IR ABSORPTION SPECTROMETER
C. R. Webster 818-354-7478

The objective of this task is the definition and development of a tunable diode laser infrared absorption spectrometer for in-situ atmospheric composition measurements under NASA's program of planetary exploration. Particular emphasis will be given to the development of a probe instrument for the in-situ sensing of Titan's atmosphere on the Saturn Orbiter/Titan Probe (SOTP) NASA-ESA joint mission, and for gas phase composition measurements on future Mars missions. The diode laser spectrometer uses several narrow bandwidth (less than or =0.0001/cm) tunable diode lasers operating near 80 K at selected, mid-infrared wavelengths (3 to 30 micrometers). For the absorption measurements, these sources are directed over an open pathlength defined by a small retroreflector located 20 cm away. Because of the high sensitivity of diode laser derivative detection methods, volume mixing ratios of approximately 1/(10 to the 9th power) should be measurable for most species of interest. For Titan, vertical profiles of the concentrations of molecules such as CH4, CO, CO2, HCN, C2H2, C2N2, C3H4, C3H8, C3HN, and C4H2 can therefore be determined, with a vertical resolution of a few km from probe entry to the surface. In addition, determination of atmospheric pressure, temperature, and scattering, i.e., nephelometry, is possible using the same instrument.

W88-70237 **157-04-80**
Ames Research Center, Moffett Field, Calif.
PLANETARY INSTRUMENT DEFINITION AND DEVELOPMENT PROGRAM: TITAN ATMOSPHERIC ANALYSIS
G. C. Carle 415-694-5765
(199-52-52)

The objective of this research is to develop flight instrument capability and hardware prototypes for the comprehensive analysis from an entry probe of the gases and aerosols in the atmosphere of Titan and for the in situ from penetrators study of the physical structure of small astronomical bodies.

W88-70238 **157-04-80**
Goddard Space Flight Center, Greenbelt, Md.
DEVELOPMENT OF 3D PLASMA INSTRUMENTS WITH TIME-OF-FLIGHT MASS ANALYSIS
Edward C. Sittler, Jr. 301-286-9215

The objective of this RTOP is to develop a light weight, low power and fast 3D plasma instrument that will use time-of-flight technology for mass discrimination of ions in space plasmas. This instrument, which will be able to handle particle counting rates exceeding 10 to the 5th power Hz is presently being developed under the Planetary Instrument Definition and Development Program (PIDDP) for the Cassini mission to Saturn. This instrumentation will also have general applicability for other future missions requiring in situ measurements of space plasmas. The approach will be to develop high speed time-of-flight (TOF) electronics that will convert the time interval (20 nsec to 500 nsec) between start-stop pulses from the TOF detection unit--consisting of carbon foil, electrostatic mirrors, and microchannel plates--into a digital word that will then be used to generate a mass spectrum using a microprocessor based system. These electronics will be able to handle counting rates exceeding 10 to the 5th power Hz with power levels less than 1 watt. A light weight TOF unit will be developed which will be composed of a thin carbon foil (2 micrograms per sq cm), electrostatic mirror system, solid state detector (or metallic target) and microchannel plate detectors. The fundamental design concept will be to confine almost all the electronics at ground potential, while the TOF unit will be at high voltage (35 kV). This design concept must be able to handle launch conditions.

W88-70239 **157-05-50**
Ames Research Center, Moffett Field, Calif.
HIGH PRECISION PHOTOMETER
W. J. Borucki 415-694-6492

The main objective of this proposal is to develop data analysis techniques and instrumentation to detect other solar systems by searching for planetary transits. Although the major planets can be detected by the photometric method through the terrestrial atmosphere, the detection of earth-sized planets requires a precision of 1 part in 100,000 for a signal-to-noise ratio of 10. This precision has only been obtained outside the atmosphere by the radiometer aboard the Solar Maximum Mission. Our plan is to develop a multi-star photometer with the same precision and to operate it aboard the space station. Prior to its space deployment, a ground-based prototype photometer will be developed and tested to search for large planets. The instrument design is based on the concept of quantum perfect cryogenically cooled detectors coupled to a wide-field-of-view telescope by optical fibers. Tests of the prototype photometer are carried out at Lick Observatory. The theoretical effort is directed toward developing data analysis techniques capable of making photometric transformations at the required precision.

W88-70240 **157-05-50**
Goddard Space Flight Center, Greenbelt, Md.
PLANETARY INSTRUMENT DEVELOPMENT PROGRAM/PLANETARY ASTRONOMY
M. J. Mumma 301-286-6994

This RTOP supports the development of components for advanced generation infrared spectrometers for planetary observations. Task-02 addresses the development of compact, power efficient infrared heterodyne spectrometer components suitable for eventual space flight use. Particular emphasis is placed on development of excited waveguide CO2 lasers, and miniaturized integrated spectral line receivers.

Solar Terrestrial and Astrophysics ATD

W88-70241 **159-30-01**
Marshall Space Flight Center, Huntsville, Ala.
ADVANCED SOLAR OBSERVATORY DEFINITION
William T. Roberts 205-544-0621
(159-30-01)

The sun represents a sample of astronomical matter lying figuratively at our doorstep in which many of the physical processes which operate on stellar and galactic scales can be studied at a level of detail that can be achieved in no other way. Examples of these fundamental processes include the release of energy by thermonuclear reactions, the generation of magnetic fields on stellar scales, the transport of energy on a variety of scales by convective processes, the acceleration of particles to ultra-high energies, and the loss of mass through the solar wind. The Advanced Solar Observatory (ASO), as proposed, will contain a complement of instruments of such enhanced power and subtlety that our understanding of solar phenomena will be immeasurably advanced. The ASO will be developed on the space station in a modular approach beginning with the High Resolution Solar Observatory (HRSO) and the Pinhole Occulter Facility (POF). This modular design will allow the addition of new capability, such as extreme ultraviolet (EUV), soft X-ray, low frequency radio, and gamma ray and neutron, as they become available.

W88-70242 **159-38-03**
Marshall Space Flight Center, Huntsville, Ala.
ADVANCED MISSION STUDY: SOLAR X-RAY PINHOLE OCCULTER FACILITY (POF)
Joseph Dabbs 205-544-0623

Hard X-ray imaging of the sun in the range 10 to 100 keV is very important in understanding energetic processes such as solar flares of the active sun. There have been very important results in recent years in imaging hard X-rays. The Pinhole Occulter Facility (POF) is a novel instrumentation concept which uses a 32 meter deployable boom to position a mask which provides occultation for coronal telescopes. It also provides coded array and Fourier-Transform apertures for hard X-ray imaging. The purpose of the facility is to image the solar disk in the X-ray spectrum at higher energies than previously possible and to study the solar corona with greater sensitivity, to lower limb heights and with greater angular resolution. It also has the capability of imaging celestial sources in hard X-rays. The POF is intended for the space station and is also an important building block in the Advanced Solar Observatory (ASO).

W88-70243 **159-41-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A STUDY OF THE LARGE DEPLOYABLE REFLECTOR (LDR) FOR ASTRONOMY APPLICATIONS
P. N. Swanson 818-354-3273
(506-49-21)

The overall objectives of this RTOP are to provide science definition and leadership for LDR, continue pre-phase A system definition and to help define, guide and contribute to specific technology development tasks. The Science Coordination Group (SCG) will be funded under this task along with the Jet Propulsion Laboratory (JPL) LDR scientist. The Science Coordinating Group (SCG) will oversee and advise the LDR science program. The LDR technical manager will provide overall program management and also provide coordination between the various technical efforts both internal and external to JPL. In particular, coordination with the newly formed Civil Space Technology Initiative (CSTI) is an important interface function to insure that both Code E and R programs are synergistic. Most of the technology development areas defined at the previous Asilomar workshops will be addressed by the CSTI program. However, some of the LDR mission specific areas that will be addressed under this RTOP are: analysis of the sensitivity limiting background radiation from the telescope optics; further definition of the LDR mission model including orbits, viewing angles, constraints and timelines; further definition of the LDR instrument complement including spectrometers and cryogenics. To prepare for the eventual use of the CSTI developed testbed to answer specific scientific questions about LDR, it will be necessary to plan for specific tests before the final system design of the testbed is completed. Some of the specific tasks to be accomplished are long range test plans, the incorporation of the focal plane instruments into the testbed, the design and incorporation of two-stage optics into the testbed and plans for investigating methods of background suppression.

W88-70244 **159-41-01**
Ames Research Center, Moffett Field, Calif.
STUDY OF LARGE DEPLOYABLE REFLECTOR FOR INFRARED AND SUBMILLIMETER ASTRONOMY
D. J. Hollenbach 415-694-4164

The Large Deployable Reflector (LDR) will be a 20m diameter reflecting submillimeter/far-infrared telescope, constructed or deployed in space (possibly at the space station), and placed in a free-flying earth orbit to perform as an observatory for at least 10 years. It is currently in the early planning stage, and it is hoped to be operational roughly in the year 2000. Work under this RTOP is a continuation of activities to refine the scientific rationale and the related set of science requirements and to provide scientific input in defining and developing technical concepts and requirements. Problems addressed in this work often emerge from the discussions of the LDR Science Coordination Group, of LDR workshops with industrial contractors, or with the LDR lead center, the Jet Propulsion Laboratory (JPL). These problems include, for example, studies of LDR as a light bucket and the use of LDR toward specific scientific goals such as planet detection. Currently, the work, imposed by the need to achieve the desired sensitivity, focuses on thermal background subtraction by LDR using techniques such as nodding, chopping rate and temperature uniformity.

W88-70245 **159-41-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL INTERFEROMETRY IN SPACE
J. D. Burke 818-354-6363

The objective of this RTOP is to begin to explore practical implementation problems associated with a few of the spaceborne interferometric imaging concepts which have been proposed over the last half dozen years. For two significantly different strawman interferometric imaging concepts, the phased and the coherent arrays, we will lay out some practical spacecraft designs including structural, optical, controls and systems considerations. The idea will be to use these practical implementation concepts to identify technology trades which should be investigated. The work will be guided by a technical working group of astronomers and technologists from various organizations active in the field.

W88-70246 **159-41-06**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF SPACE INFRARED TELESCOPE FACILITY (SIRTF)
J. P. Murphy 415-694-6643

The objectives of this RTOP are to define and develop the Space Infrared Telescope Facility (SIRTF), to define and develop operational procedures for the SIRTF focal plane, and to develop operational procedures for SIRTF as a free flyer observatory. SIRTF is an observatory that will accept multiple focal plane instruments for use by infrared astronomers. The conceptual studies have identified the key technologies for SIRTF and for the science instruments, and technology development is being conducted. The approach for this RTOP is to continue development of the technology needed for the design and development of SIRTF and to coordinate the results of the previous studies and the technology development and to increase the depth of the design definition and systems analysis by performing Phase B studies of the telescope facility and the selected instruments.

W88-70247 **159-46-01**
Marshall Space Flight Center, Huntsville, Ala.
ADVANCED X-RAY ASTROPHYSICS FACILITY (AXAF)
D. C. Cramblit 205-544-0569

AXAF is a free-flying observatory featuring a high performance X-ray telescope for use over a 15 year lifetime through servicing from space station or Space Transportation System (STS) revisits. AXAF is now in the definition phase, aimed at long lead item development start efforts in FY88 and a launch in the 1994 to 1995 time period. Due in part to advances in metrology and fabrication technology in X-ray optics, AXAF is expected to be 50 to 100 times as sensitive as its predecessor, High Energy Astronomy Observatory 2 (HEAO-2). An ongoing technology mirror assembly program has already demonstrated the achievability of nearly all the AXAF optic goals. This RTOP activity will continue to place emphasis on the early development and demonstration of all science instrument and optics technologies critical to achieving AXAF science objectives and assuring a sound basis for program new start readiness in FY89.

W88-70248 **159-60-01**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED TECHNOLOGICAL DEVELOPMENT, GENERAL: SIGNAL AND DATA PROCESSING ELECTRONICS: CAD/CAE
D. E. Stilwell 301-286-6282

The objectives of this research project are to develop and test new on-board signal handling, processing, storage, computing and auxiliary circuitry for use in particle and astrophysics experiments on spacecraft, rockets, balloons, etc., as well as special test and analysis equipment applicable for both ground and shuttle usage. The growing complexity of experiments and the corresponding increase in the volume of data obtained have made signal handling, data processing and data transmission the capability-limiting factors. To reduce the transmission of unnecessary data and support the requirements of ever more complex instruments, it is necessary to continue to provide the maximum possible onboard data processing capability. This program is approached through: (1) the investigation and development of techniques for signal shaping and handling, data processing and auxiliary circuitry; (2) modification of existing techniques by application of advanced complementary metal oxide semiconductor/large scale integration (CMOS/LSI) and semi-custom technology for parts, and thick film, multiple chip, or surface mount technology (SMT) for packaging; and (3) establishment of a computer-aided-engineering (CAE) capability to improve design productivity and make semi-custom integrated circuit (IC) technology available for instrument designs. The objective of this task is to provide continuing maintenance and support for the laboratory's computer-aided engineering/computer aided design (CAE/CAD) development. Acquisition of the equipment (jointly with the Data Systems Directorate) is nearly complete and it is now necessary to gain familiarity with and confidence in semi-custom design techniques and sources to remain competitive in future instrument development and proposals.

W88-70249 **159-60-78**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ASTROPHYSICAL CCD DEVELOPMENT
S. A. Collins 818-354-7734

Charge Coupled Devices (CCDs) are being developed for use as camera and spectrograph detectors throughout an unprecedented spectral range: 1 to 10,000 angstroms. The objective of this task is to implement and demonstrate CCD design modifications which enhance CCD performance at X-ray and ultraviolet wavelengths. Specifically, good detection efficiency (greater than 30%) is to be achieved throughout the range of 1 to 4000 angstroms, and low read-out noise (less than 5 electrons/pixel, rms) is to be demonstrated. Our approach is to contract for modification of the design of an existing visible-light CCD, to procure such enhanced CCDs to evaluate their performance at low signal levels, and to undertake additional design and fabrication iterations as required to achieve the stated objectives.

Oceanic Processes

W88-70250 **161-10-00**
Wallops Flight Center, Wallops Island, Va.
OCEAN ADVANCED STUDIES
C. L. Parsons 804-824-1390

The objectives of this RTOP are: (1) to study advanced instrumentation concepts deemed to have potential space flight benefits for ocean color and active microwave remote sensing; (2) to participate in satellite mission definition studies as required to support future ocean program goals; (3) to improve instrument measurement quality and algorithm accuracy for altimetry and ocean color imaging; and (4) to use modern technologies to reduce power and weight constraints, to accommodate high data rates, and to minimize costs to enhance the probability of flight opportunities. With the approval of the Topology Ocean Experiment (TOPEX) as an FY87 New Start for the agency, the previous inclusion of TOPEX-related tasks in this RTOP is terminated. In FY88, there will be only two tasks, one for ocean color and one for advanced altimetry. The former is a Phase A study of the accommodation of an ocean color imager for the EOSAT satellite series. The latter task will be the final year of development of the Aircraft Multibeam Radar Altimeter (AMRA). The previous funding of the development of a precision positioning system using commercially available Global Positioning System receivers has led to the procurement of two such receivers. This year, they will be incorporated into the AMRA development activity and thereby integrated into the Goddard Space Flight Center Wallops Flight Facility (GSFC/WFF) instrumented research aircraft.

W88-70251 **161-10-08**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED SCATTEROMETRY
F. Li 818-354-2849
(161-80-39)

The objectives of this task are to develop a new airborne research scatterometer facility that can be used for geophysical research and as a testbed for new technology development and to develop advanced technology that will improve the performance of future spaceborne scatterometers. The prime FY88 objective is to continue the design, fabrication and integration of the various subsystems of the New Airborne Scatterometer (NUSCAT) so that the whole system is ready for integration, test, and calibration starting in FY89. A secondary objective is to continue the analysis of a new system concept for a spaceborne scatterometer design that will be applicable for the Earth Observing System (EOS). For the NUSCAT development, the procurement of all the items associated with the radar will be completed, all circuits will be designed and fabricated, and the computer controller software will be generated. Calibration of the various subsystem parameters, such as transmitter stability, receiver noise figure and gain stability, linearity of the A/D converters, etc., that are required prior to full system integration and test will be conducted. We will also develop, fabricate and test the high data rate recording/playback interfaces with a VAX computer. The ground data processing software development will be initiated. The plan is to conduct laboratory integration and test in early FY89, aircraft integration and test in the second quarter of FY90 leading to engineering flights in April, 1990. In FY87, we have completed a preliminary design of the scatterometer for EOS that employs conically scanning pencil-beam antennas. We will continue refining this design and will issue a small study contract on further definition of the scanning antenna system. These results will be integrated into a proposal in response to the announcement of opportunity for EOS.

W88-70252 **161-20-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DETERMINATION OF THE EM BIAS IN OCEAN ALTIMETRY
E. Rodriguez 818-354-0492

The distribution of scatterers on the ocean surface does not coincide exactly with the distribution of ocean surface heights. This phenomenon is a source of error to the height estimated by an ocean altimeter, such as the one which will be used in the Topology Ocean Experiment (TOPEX) mission. The exact nature and magnitude of this bias is not well understood. The objective of this task is to understand this bias and determine its magnitude. We will use three complementary approaches to accomplish this task. First, we will perform an experiment on an ocean platform to determine the magnitude of the bias experimentally using the two frequencies to be used by the TOPEX altimeter. In order to perform this experiment, we will build and test a dual frequency radar. This radar will be deployed jointly with an experiment to be conducted by a group from The Massachusetts Institute of Technology Scripps Institute of Oceanography (MIT/Scripps). Analysis of the collected data will be performed jointly by both teams. Second, we will investigate the possibility of estimating the magnitude of the bias from actual ocean altimeter returns by applying a deconvolution procedure which we have developed. To accomplish this, we perform Monte Carlo experiments to determine an optimum algorithm for deconvolving and estimating ocean surface parameters, including the electromagnetic (EM) bias. Using this algorithm, we will estimate the EM bias for selected geographic locations using existing Seasat and Geosat altimeter data. Finally, we will conduct numerical scattering experiments from simulated and digitized ocean surfaces to determine the scattering mechanism responsible for the EM bias. The implications of these findings on experimental EM bias data analysis will be studied.

W88-70253 **161-20-07**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CURRENTS/TIDES FROM ALTIMETRY
M. E. Parke 818-354-2739

The proposed work is intended to study a number of tidal problems that will have an impact on the analysis and use of Topology Ocean Experiment (TOPEX) data. The first six months of Geosat data will be used for a study of the deep water tides. These results will be combined with Seasat results for a paper to be submitted in this coming fiscal year. The tides in the Hudson Strait and Hudson Bay will be studied. There will be continuing work on the applicability of altimetry data to tidal models. Tidal studies are broken into two regimes, shallow water areas which are characterized by short length scales and large amplitudes, and deep water regions characterized by long length scales and small amplitudes. Deep water tides are characterized by length scales greater than 500 km and amplitudes that are typically less than 50 cm. Deep water tides are amenable to direct analysis if they can be separated from radial orbit errors and from other geophysical signals. Once results from direct analysis exceed the accuracy of the current generation of tidal models, these results can be used to improve understanding of models and of the geophysical consequences of the tides. Shallow water tides, on the other hand, are being studied with a combination of data analysis and modelling, since the spatial resolution from a single altimetric satellite will be too poor to gain a complete picture of the tide.

W88-70254 **161-25-00**
Goddard Space Flight Center, Greenbelt, Md.
OCEANOGRAPHIC SATELLITE RESEARCH
R. G. Kirk 301-286-7895

This RTOP covers pass through grant money for peer-reviewed ocean science research at universities, as well as support of science working groups.

W88-70255 **161-25-07**
Goddard Space Flight Center, Greenbelt, Md.
TELEMAIL
R. G. Kirk 301-286-7895

This RTOP covers pass through grant money for peer-reviewed ocean science research at universities, as well as support of science working groups.

W88-70256 **161-30-00**
Goddard Space Flight Center, Greenbelt, Md.
OCEAN OPTICS
C. R. McClain 301-286-5377

This RTOP is designed to develop methodologies that utilize remote (airborne and satellite) active and passive optical sensors for the purposes of investigating physical, biological and chemical processes in the ocean surface layer. Close coordination between the sensor and algorithm development and applications components of the RTOP is emphasized. Also, joint collaborations with the outside oceanographic community are stressed. The RTOP consists of six tasks, three of which are ongoing and three that are proposed. The ongoing tasks are for the Multichannel Ocean Color Scanner or MOCS (-01, Oberholtzer), mesoscale ocean processes (-02, McClain) and the Airborne Ocean Lidar (-13, Hoge). New proposals are for investigations of processes in Southeast Asia (Elrod), and the Arctic Region (Maynard), and advanced atmospheric correction algorithm development for color sensors (Mecherikunnel). The work performed under this RTOP complements basin scale studies of ocean color being performed by Esaias, McClain and Elrod which have been supported by the Interdisciplinary Studies in the Earth Sciences program (RTOP 148-30-01-20). Also, elements of the RTOP are closely coupled to the processing and archiving of the Coastal Zone Color Scanner (CZCS) data set which is being undertaken by the Nimbus Project.

W88-70257 **161-30-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OCEAN PRODUCTIVITY
M. R. Abbott 818-354-4658

Temporal and spatial variability of phytoplankton biomass and productivity is in large part a result of fluctuations in physical

processes. Long time series of satellite imagery covering a large area will be necessary if we are to understand the interactions of these biological and physical processes. To accomplish these objectives, we are engaged in five activities. First, we are developing complete time series of sea surface temperature as derived from Advanced Very High Resolution Radiometer (AVHRR) data, and near surface pigment as derived from Coastal Zone Color Scanner (CZCS) imagery from the California Current domain (20 deg N to 60 deg N) that eventually will span the lifetime of the CZCS. The requirements for these time series were established by the West Coast Satellite Time Series Advisory Group. The data are freely available through the NASA Ocean Data System. Second, we are analyzing these data, focusing on the climatology of the large filaments that move large amounts of coastal water far offshore and on the comparison of satellite data with ship surveys from the California Cooperative Oceanic Fisheries Investigations (CalCOFI). We are also comparing the relationship of the filaments to physical forcing. This research is jointly funded with the Office of Naval Research (ONR). Third, we are analyzing portions of these time series from the Coastal Ocean Dynamics Experiment area and from the shelf area off Vancouver Island (in collaboration with K. L. Denman). This effort is concentrating on estimating temporal and spatial decorrelation scales. Fourth, a graduate student at the Scripps Institute of Oceanography (SIO) (C. Tynan) is analyzing ship and satellite imagery to study the effects of the filaments on the large-scale biological patterns in the California Current. Fifth, we are investigating the effects of missing data on the reliability of sample statistics derived from the time series. Data have been distributed to investigators at the Institute of Ocean Sciences (Canada), Scripps, Ohio State University (OSU), the University of California at Santa Barbara, the Rosenstiel School of Marine and Atmospheric Science (RSMAS) and the University of Washington.

W88-70258 **161-30-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANKTON FLUORESCENCE AND PRODUCTIVITY
D. J. Collins 818-354-3473

The objective of this research is the investigation of the use of satellite imagery for the estimation of oceanic primary production on regional and global scales. The research includes laboratory and field studies of light absorption, fluorescence and photosynthesis of marine phytoplankton and the development of physiological models for the prediction of primary productivity in the upper water column. The model for primary production is based on a description of light absorption and production by phytoplankton using the near-surface distribution of oceanic pigment from the Coastal Zone Color Scanner (CZCS). The spatial and temporal distributions of primary production will be used to investigate the variability of the California Current system, and of the Gulf of California. The laboratory and field work on light absorption, fluorescence and photosynthesis includes the analysis of absorption and fluorescence spectra of marine phytoplankton populations and associated particles, focusing on the contribution of both the photosynthetic accessory pigments and detrital pigments to the absorption spectra of suspended marine particles. We will compare spectral deconvolution, spectral derivative analysis and the determination of empirical orthogonal functions to interpret in situ and remote sensing data obtained from the phytoplankton community in the ocean and to investigate the means by which the photoadaptive state and taxonomic distributions of phytoplankton may be distinguished in oceanic waters.

W88-70259 **161-30-19**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
WEST COAST SATELLITE DATA VISUALIZATION
M. R. Abbott 818-354-4658
(161-30-02)

The West Coast Time Series project has produced a large number of data files containing satellite-derived geophysical measurements of near-surface phytoplankton pigment and sea surface temperature (SST). These files are in a format amenable to display as images. The data comprise a time series showing the mesoscale physical dynamics of California Current Surface waters as manifested in the patterns of surface pigment and SST and the time history of persistent features such as coastal jets associated with headlands or upwelling zones. To visualize these dynamics it is necessary to improve on the current practice of viewing images one at a time. We propose to use the capability of the Digital Image Animation Laboratory (DIAL) at JPL to accomplish this. The DIAL is a facility that produces and animates digital images. They can provide direct digital to analog conversion capability to produce broadcast quality videotape. They also use the mature, versatile, well-developed VICAR software packaging for image processing. We will provide a set of digital images upon which the video will be based. The interpolation schemes used will have a basis consistent with values in the California Current System. Production of interpolated synthetic images produced will be supervised by M. Abbott to ensure scientific credibility of the product. We will produce a videotape of West Coast Time Series SST imagery that shows via animation the dynamics of this important and interesting oceanographic region. We will utilize products already created by the West Coast Time Series project. Effort will be made to maximize both scientific credibility and aesthetic acceptability of the product.

W88-70260 **161-40-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ACTIVE/PASSIVE SEA ICE ANALYSIS
F. D. Carsey 818-354-8163

Our objective remains to learn more about the processes at work in ice covered seas. The key tools for this work are satellite sets, notably the active microwave data sets as from Synthetic Aperture Radar (SAR). Our work is focused on obtaining more information on ice kinetics, type and conditions and ice backscatter behavior, especially for measurements taken at C-band, the frequency to be used in the spaceborne systems to be flown for the first time next decade by Europe. We also plan to initiate work on utilization of polarization information such as will be acquired by the Earth Observing System (EOS) SAR by examining aircraft data proposed for October 1988. Toward those ends we have initiated collaboration with the Labrador Ice Margin Experiment (LIMEX) organized by Canada and involving scientists from the Scott Polar Research Institute (SPRI) in the U.K. and the Alfred Wegener Institute in the Fed. Republic of Germany as well as other U.S. researchers. The first LIMEX field program was in March, 1987; three Jet Propulsion Laboratory (JPL) scientists participated. We intend to continue the development of automatic processing algorithms for ice kinetics and type. Data from the Shuttle Imaging Radar flight series and from aircraft will be used for certain types of information. The use of SAR to study waves at the ice margin will be pursued if the current work seems to indicate value. The overall objectives of the program are to increase our knowledge of the geophysics of ice covered seas and to advance the technology of SAR in the observations of sea ice processes. Our approach will include tasks to: (1) develop a data set on aircraft C-band sea ice observations in a number of areas and seasons; (2) learn more about the sub-mesoscale motion of ice and about the geophysics of ice motion; (3) continue to develop computer methods for the extraction of ice geophysical information from SAR images; (4) quantitatively evaluate the behavior of the air-sea-ice system at the ice margin as regards such processes as grease ice formation, swell propagation, floe size and form, and eddy presence; and (5) to take advantage of flights of opportunity over the Southern Ocean to learn about the kinematics and structure of the ice. Aircraft data from the JPL SAR aboard the NASA DC-8 may be available in 1988 for both the Chukchi Sea and Antarctica, although the Antarctic work is not yet in the planning stage.

W88-70261 **161-40-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DETAILEE/NJOKU
C. Elachi 818-354-5673

The objective of this RTOP is to provide support to the Oceanic Processes Branch, Earth Science and Applications Division, by

the assignment of a Jet Propulsion Laboratory (JPL) detailee to NASA Headquarters. The primary duties of the detailee will be to coordinate present and future activities of the Ocean Data Systems program, and to assist in the development of future directions for this program.

W88-70262 **161-40-05**
Goddard Space Flight Center, Greenbelt, Md.
ARCTIC SEA ICE
D. J. Cavalieri 301-286-2444

The objective is to perform research on sea ice, ice shelves, and continental ice sheets and related oceanographic and climatological processes and their impact on global change. The RTOP supports the Oceans, Ice and Climate Programs and the end objectives of understanding, predicting and managing the environment. The activities involve observational studies of air-sea-ice interactions, modeling of the polar sea ice covers, field programs in the Antarctic and Arctic, and analysis of data from previous experiments including the Marginal Ice Zone Experiments in the Bering and Greenland seas. Deep water formation in the central Arctic and in the Greenland Sea is a problem of fundamental importance to deep ocean circulation and meridional heat transport in the oceans. Related studies include the role of Arctic polynyas in the heat budget and water mass structure of the Arctic ocean and the variability of surface heat flux in the Greenland and Norwegian seas. Additional activities include shelf ice studies, ice sheet mapping, and sea ice transport processes. The refinement of sea ice algorithms for use with passive microwave radiometry, analysis of Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR) data and work on the Nimbus-5 Electrically Scanning Microwave Radiometer (ESMR) Arctic sea ice atlas are all continuing activities. New initiatives include the use of Landsat and Synthetic Aperture Radar (SAR) imagery to assist in the interpretation of ice sheet features, and the application of Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSMI) data to sea ice studies.

W88-70263 **161-40-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NASA OCEAN DATA SYSTEM (NODS)
J. C. Klose 818-354-5036
(656-13-40)

The objective of the NASA Ocean Data System (NODS) is to archive and distribute data sets from spaceborne ocean viewing sensors and, to a limited extent, data sets from in-situ measurement systems. NODS will provide a catalog of data sets relevant to ocean science that can be interrogated interactively. Interactive access will be provided to a bibliography system which provides abstracts of documents relevant to data sets referenced in the catalog or held by the archive. NODS will archive data at various processing levels, ranging from levels 0, 1, and 2 swath-oriented data to levels 3 and 4 gridded data. NODS will produce and archive browse products which are designed to provide rapid response to users wishing to browse through data interactively. Users will be able to select data by time, region, project, sensor, data level, and measurement. Selected data can be displayed at the user's terminal, electronically transmitted to the user or written to magnetic or optical media for shipment to the requester. NODS exists to serve the data needs of researchers in NASA's oceanography program and in the wider community of NASA-associated ocean research programs such as the World Ocean Circulation Experiment (WOCE), the Tropical Ocean/Global Atmosphere (TOGA) program, and GOFS. NODS is a computer-based distributed system of archive and catalog nodes and user terminals or workstations, linked together by a computer network. NODS archive nodes contain data from NASA oceanographic spaceborne sensors, allied non-NASA oceanographic spaceborne sensors, and allied oceanographic in situ sensors. NODS, in the strict sense, refers to those components of the distributed system described above funded directly or indirectly by NASA. NODS may interface with other NASA disciplinary or interdisciplinary data systems such as the NASA Climate Data System (NCDS) and the Central On-line Data Directory (CODD), and with data systems of other agencies such as the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation (NSF), and the U.S. Geological Survey (USGS). NODS may eventually become integrated into an interagency ocean science or earth science data system. NODS may also develop network connections and data or metadata exchange standards and agreements with ocean-related data systems of other countries (e.g., Europe, Canada, Japan). This RTOP's change in scope is due to the inclusion of tasks performed under RTOP number 656-13-40 in FY87.

W88-70264 **161-40-11**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ERS-1 SAR
C. Elachi 818-354-5673
(656-62-01)

The long term objective of a geophysical processor development for ice studies is to develop an automated data system for classification of ice types and extraction of ice motion parameters from multi-date Synthetic Aperture Radar (SAR) imagery. The goal is to provide data products that can be directly utilized for the analysis of large-scale ice dynamics in the polar regions as well as for practical applications such as navigation and deployment of drilling platforms. As a means to this goal, new data extraction and image processing techniques will be developed under this RTOP and integrated into an operational system for ice information extraction from SAR imagery. This system will be evaluated using Seasat imagery, with the eventual application of the operational system to process ESA Remote Sensing Satellite 1 (ERS-1) data acquired at the Alaska SAR Facility (ASF) and data from the Earth Observation System (EOS) SAR. The approach is to develop techniques for ice classification and for two-dimensional motion tracking and to evaluate system architectures that would maximize the autonomy and enhance the performance of the data system. Ice motion tracking is a complex problem due to the translation, rotation and deformation of the different ice types because of the high spatial temporal variability of sea ice. The primary tasks include: (1) development of contextual classification techniques for categorization of sea ice; (2) development of feature tracking techniques for identification of image sequences; (3) reasoning methodologies for utilization of spatial constraints and motion predicts from ice dynamics models; and (4) evaluation and testing of system architectures that are optimal to the implementation of such a system.

W88-70265 **161-40-30**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NASA/NOAA SATELLITE OCEANOGRAPHY
J. P. Crawford 818-354-6471

The objective of this research is to advance our understanding of the geophysical processes of the Chukchi/Bering Sea system and its seasonal changes in ice cover, and to develop relationships between measured radiances and derived geophysical parameters from the Special Sensor Microwave Imager (SSMI) sensor with actual surface conditions. We will evaluate various geophysical algorithms that depict the ice edge and summarize total ice concentration for the Bering and Chukchi Seas. The scientific issues concerning the Chukchi Sea involve understanding the effects of heat transported by bathymetrically channelled flow through the Chukchi, the processes influencing the ice edge, and the role of the continental shelf break during ice retreat. The proposed effort will seek to understand the relationships between radiances and derived sea ice products from available algorithms for the SSMI sensor, which is scheduled for launch in June 1987. The approach in examining the above science issues involves analyses of historical microwave, thermal and visible satellite observations, and available aircraft measurements in conjunction with oceanographic and atmospheric data sets. This includes participation in arctic field programs designed to verify satellite measurements, experimenting with computer technologies to combine satellite data from different platforms and sensors, and conducting statistical analyses to help evaluate the results of various geophysical algorithms.

W88-70266 **161-50-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OCEANIC REMOTE SENSING LIBRARY
J. E. Hilland 818-354-4787

The objectives of this RTOP are to: (1) provide contemporary literature on and related to remote sensing of the oceans; (2) provide a comprehensive set of services for oceans researchers who are the patrons of the Oceanic Remote Sensing Library (ORSL); and (3) to implement labor-saving methodologies for the distribution of literature. The objectives of this task are met by the ORSL librarian. Organization, maintenance and distribution of 189 titles and a bibliography containing more than 2300 entries are the responsibilities of the librarian. The primary focus of the literature collection is high quality oceanography periodicals and NASA, Department of Defense (DOD), National Oceanic and Atmospheric Administration (NOAA) and European Space Agency (ESA) internal documents (grey literature). The Library of Congress classification system is used to organize the documents. An on-line, computer based bibliography provides search and order capabilities to all users of the NASA Ocean Data System. The ORSL librarian is responsible for the compilation and maintenance of bibliography contents. Comprehensive services provided to patrons consist of document loan, interlibrary loan, literature search, ORSL newsletter preparation, and document acquisition. Furthermore, ORSL distributes the NODS User Handbook. Requests for service are made via mail, telephone, walk-in and the NODS on-line bibliography.

W88-70267 **161-50-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OCEAN PROCESSES BRANCH SCIENTIFIC PROGRAM SUPPORT
C. Elachi 818-354-5673

The objective of this task is to support the NASA Oceanic Processes Branch in the development and use of remote sensing techniques to study physical and biological oceanic processes and their interactions with the atmosphere.

W88-70268 **161-50-06**
Goddard Space Flight Center, Greenbelt, Md.
PROGRAM SUPPORT
Erik Mollo-Christensen 301-286-6171

The objective of this RTOP is to support Oceanic Processes research activities.

W88-70269 **161-50-07**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ANALYSIS OF OCEANIC PRODUCTIVITY
C. O. Davis 818-354-5395

This is a new research effort initiated in FY87 on return of C. O. Davis from NASA Headquarters. The research focuses on the use of Advanced Very High Resolution Radiometer (AVHRR) Sea-Surface Temperature and Coastal Zone Color Scanner (CZCS) ocean color data for the study of primary productivity and phytoplankton dynamics in California coastal waters and the California Current. Initially, the focus is on using extensive in situ data for verification and interpretation of the satellite data. Subsequently, the goal is to use the satellite data coupled with a physical-biological model to extrapolate those results in time and space. The first study area is around Point Conception where extensive circulation and primary productivity data were collected in 1981 and 1983 during the National Science Foundation (NSF) sponsored Organization of Persistent Upwelling (OPUS) program. Following that initial study the 1981 and 1983 results will be used to interpret the entire seven year West Coast Time Series data set for the Point Conception area. The Point Conception area is unique because it is a right angle bend in the coastline and thus forms the southern end of the Coastal Upwelling region. The OPUS data set is the best available for this work; however, for a more general case I will also initiate a study of the Point Arena area in collaboration with Mark Abbott. In situ data for that area exist from the NSF sponsored Coastal Ocean Dynamics Experiment (CODE), and an additional data set will be collected in 1987 and 1988 as part of the Office of Naval Research (ONR) sponsored Coastal Transition Zone (CTZ) program. The CTZ program also includes the development of a coupled physical-biological model which, eventually, we plan to use in our analysis of the satellite data.

W88-70270 **161-60-15**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
JPL OCEANOGRAPHY GROUP PLAN FOR A COMMON COMPUTER SYSTEM
R. E. Glazman 818-354-7151

The project will provide a multi-user computer system serving the basic computing and data management needs of the JPL Oceanography Group. The system is based on clustered workstations with shared peripherals, which will be accessible to all members of the group. The need for the Ocean Computing System is dictated by the growing number of research projects undertaken by the group, as well as by the necessity to free the NASA Ocean Data System (NODS) Vaxes from other tasks and make them available for the sole use of NODS, thus making room for Special Sensor Microwave Imager (SSM/I) operations. The new computing facility will allow the JPL oceanographers to meet the demands of a drastically increased flow of data from the Tropical Ocean/Global Atmosphere (TOGA) Heat Exchange Project (THEP) and from the Geosat mission. Presently the Oceanography Group includes 28 people and carries out a total of 22 research projects in physical, biological and polar oceanography. Some projects depend on interactions and exchange of data between individual investigators. This requires a common computing facility capable of storing and processing large volumes of data in real time. Diversity of individual tasks undertaken by the group members makes it necessary to provide standard as well as special software packages plus flexible communication capabilities. In addition to this system, the group has now started using the Sun 3/160M workstation contributed by one of the members (Mike Parke) to support Geosat data analysis and word processing efforts of the group. The maintenance of this computer will be carried under the Group Computing Plan.

W88-70271 **161-80-15**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REMOTE SENSING OF AIR-SEA FLUXES
W. T. Liu 818-354-2394

The long-term objective is to study the interactive processes of ocean-atmosphere energy exchanges using spaceborne sensors. The short-term objectives are to develop and implement methods of determining latent heat flux from the ocean using satellite data and to apply the flux to study the 1982 to 1983 El Nino and Southern Oscillation (ENSO) episode. Initial feasibility studies have been performed based on Seasat Scanning Multichannel Microwave Radiometer (SMMR) data. A global relation between precipitable water measured by spaceborne sensors and surface-level humidity required to determine latent heat flux has been established. Nimbus/SMMR data from 1980 to 1983 have been evaluated and corrected. The study of annual and interannual variabilities in the tropical Pacific based on this set of data is in progress. The Tropical Ocean/Global Atmosphere (TOGA) Heat Exchange Project (THEP) has been established as an attempt to produce a validated satellite data set for computing the net surface heat flux in conjunction with the Tropic Heat and TOGA experiments. New methods to improve the accuracy and temporal resolution of the satellite heat flux are being studied. Diagnostic models to link atmospheric forcings to oceanic dynamics will be developed. Evaluations and applications of Geosat/altimeter and Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSMI) data in the Ocean Storm experiment are under consideration.

W88-70272 **161-80-37**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THEORETICAL/NUMERICAL STUDY OF THE DYNAMICS OF OCEAN WAVES
M. H. Freilich 818-354-7801

The overall objective of this work is to develop realistic models describing wave-induced water motions in the nearshore environment (depths less than 10 m). Specifically the one-dimensional shoaling model of Freilich and Guza (1984) must be extended to account for the effects of non-normal incidence and non-planar bottom topography. This work is part of a larger project, Development and Testing of Shoaling Region and Surf Zone Nonlinear Wave Models (co-investigators Guza of the Scripps Institute of Oceanography, Freilich of the Jet Propulsion Laboratory, Elgar of WSU, accepted and funded by the National Science Foundation with starting date 15 January 1987). Much theoretical work has been done, and field data acquired, relating to wave transformations in shallow water. The 1-D shoaling model of Freilich and Guza has been shown to predict accurately a variety of features of the shoaling wave field. The model will be extended to two dimensions to include refractive effects and to allow prediction of longshore currents and reflection. Using high-quality data acquired in the past, detailed analyses of both the nonlinear interactions occurring in the shoaling region (bispectral analysis) and the 2-D evolution/refraction of the wave field (measured by multiple direction arrays) will guide the model extensions and allow testing of model results. Detailed characterizations of the shoaling wave field are thus derived first, followed by comparisons with 1-D model results and theoretical extensions to the model, and finally testing of the extended model against independent (but already available) data. Large-scale computing facilities necessary to run the 1-D and 2-D nonlinear models have been acquired from the San Diego Supercomputer Center through the National Science Foundation (NSF) proposal and through auxiliary direct letter proposals (Elgar and Freilich, Numerical Integration of Nonlinear Shoaling Wave Models).

W88-70273 **161-80-38**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OCEAN CIRCULATION AND SATELLITE ALTIMETRY
L.-L. Fu 818-354-8167

The long-term objective of the research activities covered under this RTOP is to investigate the utility of satellite altimetry for observing the general circulation and variability of the oceans. The approach taken is to analyze Geos-3, Seasat, and Geosat data using the techniques of crossover difference, repeat track difference, and mean sea surface mapping. Following are some near-term objectives: (1) creation of a Geosat data processing facility to perform data quality analysis, data analysis, data inventory, and data reduction for research use; (2) investigation of the global mesoscale variability using Geosat data; (3) investigation of the variability of the Antarctic Circumpolar Current using Geosat data; and (4) investigation of the Geosat altimeter tracker performance and the utility of waveform data for correcting height biases. The work under objective 1 is a new task for this RTOP.

W88-70274 **161-80-39**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SCATTEROMETER RESEARCH
F. Li 818-354-2849
(161-10-08)

The objective of this task is to improve the understanding of the quantitative relationship between radar backscatter from the ocean and basic geophysical parameters of interest to oceanography and meteorology, such as surface wind stress. The prime FY88 objective is to conduct sigma(0) measurements using the Airborne Microwave Scatterometer (AMSCAT) during the Ocean Storms Experiment in October/November of 1987. We will complete the reduction of the AMSCAT data from Ocean Storm to sigma(0) and begin the evaluation of the geophysical model at the high wind speed regime. We will also finish the analysis of the AMSCAT data obtained during the Frontal Air-Sea Interaction Experiment (FASINEX) and relate the sigma(0) to the in-situ measurements. The Ocean Storms Experiment is planned to study the air-sea interaction processes during high wind storm passages. We will conduct a field experiment using the 14.6 GHz AMSCAT onboard the NASA Ames C-130B. We plan to collect sigma(0) data around a buoy array that is situated in the Gulf of Alaska approximately 400 miles west of Seattle. The data flights will be conducted immediately before and after frontal passages through the buoy array in order to avoid precipitation. A total of six to seven flights will be conducted with approximately two hours of on-site data collection time per flight. The data collected will be reduced to sigma(0) in FY88 and the analysis of the sigma(0) versus in-situ data will be initiated. The final data analysis will be completed in FY89. In FY87, we have completed two case studies using the AMSCAT data obtained during FASINEX. In FY88, we will complete a final report on the detailed comparison of the entire sigma(0) data set with all available in-situ data. The AMSCAT data will then be properly organized and archived for future use.

W88-70275 **161-80-40**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STUDIES OF SEA SURFACE TOPOGRAPHY AND TEMPERATURE
V. Zlotnicki 818-354-5519

The overall goal of this work is to increase the applicability of satellite altimetry and other satellite-sensed quantities to ocean circulation problems. The first objective for the coming year is to retrieve the variations of sea surface height in the equatorial Atlantic associated with the equatorial countercurrent, using Geosat data. A second objective is to evaluate the possibility of extending the coverage of one oceanographic component of altimetric data to a certain width across its track, by using its correlation with sea surface temperature data, imaged by Advanced Very High Resolution Radiometer (AVHRR) instruments aboard National Oceanic and Atmospheric Administration (NOAA) satellites. Geosat altimetry data will be explored for consistency, errors, corrections, etc. Geosat altimetry will be compared to tide gage data. A crossover adjustment in the equatorial Atlantic will be performed to remove residual orbit error. The altimetry will be gridded to a uniform space-time grid. For the second objective, the approach explored is the optimal estimation of the altimetric field using an anisotropic covariance function derived from a temperature image coincident in time with the altimetric data. The principal investigator will devote half time to this task and half to the scientific direction of NASA's Ocean Data System.

W88-70276 **161-80-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EFFECTS OF LARGE-SCALE WAVE-FIELD COMPONENT ON REMOTE SENSING MEASUREMENTS OF WIND AND WAVES
R. E. Glazman 818-354-7151

Analyses of errors in wind, wave and sea level measurements by microwave remote sensing techniques (satellite scatterometer, radiometer, altimeter) reported in recent years indicate that our understanding of basic mechanisms determining remote sensing signatures and the algorithms used to infer geophysical information from such measurements need improvement. The proposed research is aimed at advancing our understanding of such mechanisms for a specific case of a well-developed sea state in an open ocean. Its specific objectives are: (1) to investigate those geometrical properties of the surface that appear in a well-developed sea and lead to biases in wind, wave height and sea level measurements; (2) to quantify the corresponding error trends and relate the biases to the pertinent wind-wave factors; (3) to facilitate improvement and development of algorithms for the extraction of geophysical information from the backscattering radar cross section (scatterometer and altimeter), from the radio-brightness temperatures obtained from the Scanning Multichannel Microwave Radiometer (SMMR) and the Special Sensor Microwave Imager (SSM/I) and from the wave form of the return pulse obtained from the Geosat altimeter. With this purpose, Seasat-A Satellite Scatterometer (SASS), SMMR, SSM/I and Geosat altimeter data will be analyzed together with the in situ wind and wave measurements available from the National Oceanic and Atmospheric Administration (NOAA) Data Buoy Office (NDBO) network. This analysis will be accompanied by theoretical studies of sea surface geometrical features characteristic of a well-developed sea. The attention will be focused on intermittently occurring steep and breaking wavelets and on non-Gaussian

properties of a broad-banded random surface. In parallel with the above research, a second effort will be initiated in the area of ocean mesoscale dynamics. The processes of lateral entrainment/detrainment at the Gulf Stream boundaries will be studied based on the sea surface temperature (SST) data from the Advanced Very High Resolution Radiometer (AVHRR). This work will include development of appropriate statistical techniques for analysis of SST images when SST variations occur in a broad range of scales and intermittency of lateral exchange processes is one of the major features of the problem.

W88-70277 **161-80-42**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LARGE SCALE AIR-SEA INTERACTIONS
D. Halpern 818-354-5327

Satellite observations of sea surface temperature (SST), winds, and sea surface topography and in situ surface wind and upper ocean current and temperature measurements recorded in the equatorial zones of the Atlantic and Pacific Oceans are being analyzed to determine the primary phenomena responsible for large scale SST variations. Also, relationships between ocean color observations, involving, for instance phytoplankton pigment concentrations, and the aforementioned physical parameters are being examined. Primary components of the composite data set include: (1) moored measurements recorded in the Pacific during 1979 to 1985 as part of the Equatorial Pacific Ocean Climate Studies (EPOCS), the North Pacific Experiment (NORPAX), and the Tropic Heat project; (2) Seasonal Response of the Equatorial Atlantic (SEQUAL) Francais Ocean et Climat dans l'Atlantique (FOCAL) measurements in the Atlantic; (3) Philander's tropical ocean general circulation model data; and (4) Seasat, Geosat, Nimbus-7, and Advanced Very High Resolution Radiometer (AVHRR) observations. Scientific objectives include description of the spatial and temporal scales of surface wind field in each equatorial ocean (Seasat and perhaps Nimbus-7 and Geosat data); relationship of eastward penetration of 40- to 50-day surface wind oscillation in Pacific (moored data) and SST (AVHRR or Nimbus-7); 20-day current oscillations in Pacific equatorial zone (moored data) and SST pattern; equatorial undercurrent dynamics based on zonal slope along equator of Geosat data, wind product data, Tropical Ocean/Global Atmosphere (TOGA) in situ observations, and Philander's model data; comparative features of annual cycles of wind and current along Pacific and Atlantic equators (moored data); physical control of large scale, enhanced phytoplankton abundance distribution (Nimbus-7 and variety of physical data); Sverdrup balance of tropical currents (Geosat and wind product data); geostrophic and Ekman heat transports in tropical regions; influence of horizontal and vertical advection upon large scale SST variations; calibration of Nimbus-7 winds (Nimbus-7 and moored data). Pre-Topography Experiment (TOPEX)/Poseidon and pre- NASA Scatterometer (NSCAT) studies include: development of ocean general circulation modeling activity for data assimilation and for interpretation of oceanic boundary conditions observed by satellites; analyses of Geosat altimetry data; and analyses of Seasat and Geosat wind data.

W88-70278 **161-80-43**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE OCEANOGRAPHY
W. C. Patzert 818-354-4199

The long-term objective is to advance our understanding of the large-scale, long-term oceanographic and meteorological processes that control the oceans' role in climate variability. In particular, this research is aimed at the eventual utilization of the spaceborne data that is anticipated from the NASA scatterometer (NSCAT) and the U.S./French Topography Experiment (TOPEX)/Poseidon altimetric mission. In preparation for these future missions, analyses will be conducted with altimetric data now becoming available from the U.S. Navy Geosat mission and the scatterometer data from the Seasat Scatterometer (SASS). For the Geosat data, the objective will be to describe the variability of sea surface topography in the tropical Pacific during the 18 month Exact Repeat Mission (ERM), from November 1986 to approximately June 1988. Of particular interest is the possibility of describing the annual cycle of sea level (circulation) variability for the tropical Pacific during 1987. In collaboration with Mike Frelich, a study will be initiated utilizing two weeks of a dealiased Seasat SASS data set that has been incorporated into meteorological prediction model runs by the European Center for Medium-range Weather Forecasting (ECMWF). In this base study, the aim is to demonstrate the usefulness of global scatterometer data to future altimetric satellite missions which will require a knowledge of the oceanic sea-level pressure fields (computed from scatterometer data) in order to correct for the inverse barometer effect on the local calculation of sea surface topography. Two papers on the analysis of satellite tracked drifting buoy data from the tropical Pacific Ocean will be completed and submitted for publication. In summary, the near-term plan is to complete drifting buoy research and focus on the development of techniques for the scientific analysis of available scatterometer and altimetric data with the long-term intent of preparing for the future flights of NSCAT and TOPEX/Poseidon.

W88-70279 **161-80-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DATA ASSIMILATION AND OCEAN GENERAL CIRCULATION MODEL
D. Halpern 818-354-5327

Ocean general circulation models (OGCM) maximize the utilization of global satellite data, i.e., an OGCM propagates satellite surface information throughout the ocean's interior. The models make possible multidisciplinary studies of large scale phenomena, for example physical control of phytoplankton abundances. Also, interpretation of OGCM data combined with satellite data sampling characteristics and errors will optimize designs and strategies of future satellite missions. This RTOP emphasizes assimilation of satellite and in situ data into OGCMs and interpretation of the model data to understand the physical and biological dynamics of the global ocean. This OGCM RTOP will not focus upon model development. Models will run at the San Diego Supercomputer Center (SDSC). Initially, University of California at Los Angeles (UCLA) technical staff, who are fully experienced with atmospheric general circulation models run at SDSC, will import an OGCM to the SDSC. Meteorological fields for the OGCM will be available from UCLA and the Jet Propulsion Laboratory (JPL), and from other institutions. Scientific collaboration will occur with the academic community, NASA Centers, and other government agencies. The first model to be imported will be G. Philander's tropical OGCM, which is also of interest to other JPL RTOPs (e.g., Fu, Liu, Patzert, Zlotnicki, Collins, Davis). This OGCM also binds together several JPL activities, e.g., the Tropical Ocean Global Atmosphere (TOGA) Heat Exchange Project (THEP), the NASA Scatterometer (NSCAT), and the Topography Experiment (TOPEX). The initial OGCM-satellite investigation will be an assimilation of THEP air-sea fluxes and UCLA or European Center for Medium-range Weather Forecasting (ECMWF) surface winds to study the influence of horizontal and vertical currents upon Tiros-N sea surface temperature (SST) and Nimbus-7 ocean color distributions. Other FY88 to FY89 investigations are sea surface temperature response to different global surface wind products (all equally adequate) to highlight the substantial contribution to be made by NSCAT, and assimilation of Geosat surface height data as a surface boundary condition to estimate heat transports. After suitable demonstration of effective implementation and scientific utilization of OGCM-satellite technology, a long-range plan will be developed.

Tropospheric Air Quality

W88-70280 **176-10-03**
Goddard Inst. for Space Studies, New York, N.Y.
GLOBAL TROPOSPHERIC MODELING OF TRACE GAS DISTRIBUTION
Michael Prather 212-678-5625

The objectives of this RTOP are to contribute to an understanding of global budgets for chemically and radiatively important trace gases and to an assessment of human impact on atmospheric composition, and to determine measurement requirements and sampling strategies for a tropospheric chemistry program and aid in interpretation of observations. The approach will involve 3-D studies of trace gas distributions in cooperation with McElroy/Wofsy (Harvard University). A progressive series of studies of trace gases will be employed. Chlorofluorocarbons, source known will check the ability to model global/regional transport including stratospheric/tropospheric exchange. Methyl chloroform, source known, will check the chemistry involving OH. Carbon monoxide, sensitive to OH, provides information on sources. Other trace gases will be studied as well. The three-dimensional (3D) model will be used to support field programs and identify sources from global/regional observations. Trace gas transport will be coupled to dynamics and physics, including parameterizations, in the general circulation model (GCM). Expected results include the determination of the OH content of the troposphere consistent with observations of trace gases, and validation of 3-D chemical tracer models for further predictive studies.

W88-70281 **176-10-17**
Goddard Space Flight Center, Greenbelt, Md.
TROPOSPHERIC PHOTOCHEMICAL MODELING
A. M. Thompson 301-286-2629

The objectives of this RTOP are to understand atmospheric methane (CH4) sources and their isotopic composition, factors affecting CH4 photochemical lifetime (coupling of CH4-OH-NMHC-O3-CO photochemistry), and reasons for recent increases in atmospheric methane concentrations; and to predict the concentrations of CH4 in the next 50 to 100 years. The approach will be to combine theoretical (modeling) and experimental methods. Modeling will focus on diagnostic studies using 1-D and 2-D-diagnostic models developed over past 3-year study. Predictions of future methane levels may be carried out with a simplified assessment model being developed at the Goddard Institute for Space Studies (GISS). Experimental work will emphasize determination of methane fluxes (and isotopic composition) in Alaskan tundra as part of the NASA field program Global Tropospheric Experiment Amazon Boundary Layer Experiment 3 (GTE/ABLE 3). Methane data will be analyzed using a combination of boundary-layer modeling and chemometric statistical techniques. Expected results include a better understanding of methane and its role in the atmosphere, specifically: (1) quantification of one or more sources; (2) causes and effects of perturbed methane, including links with changing stratospheric chemistry and climate; and (3) a better description of tropospheric chemistry for incorporation into stratospheric models.

W88-70282 **176-20-99**
Ames Research Center, Moffett Field, Calif.
GLOBAL TROPOSPHERIC EXPERIMENT AIRCRAFT MEASUREMENTS
H. B. Singh 415-694-6769

The objective of this program is to provide atmospheric measurements aboard NASA aircraft to support the science goals of the Global Tropospheric Experiment (GTE). The approach is to develop and test airborne instrumentation, integrate it on the aircraft platform (Electra, DC-8), operate it during GTE flights, provide data as required by the GTE project office, and analyze, interpret, and publish individual and/or collaborative results.

W88-70283 **176-40-11**
Wallops Flight Center, Wallops Island, Va.
AIRCRAFT NOX INSTRUMENT
A. L. Torres 804-824-1553

The objectives of this RTOP are to support the addition of nitrogen dioxide (NO2) and total reactive nitrogen (NOY = NO + NO2 + HNO3 + HO2NO2 + HNO2 + 2N2O5 + NO3) measurement capabilities to the Wallops nitric oxide (NO) system, and to use the enhanced system in support of the Global Tropospheric Experiment (GTE) field measurement programs. A sensitive detector for atmospheric NO, based on the chemiluminescence technique, was developed for airborne use in early phases of the GTE program. It was thoroughly tested during the Chemical Instrumentation Test and Evaluation 1 (CITE 1) missions, and used in the Amazon Boundary Layer Experiment (ABLE) 2A and ABLE-2B. This RTOP will support the expansion of this system to include the measurement of NO2 and NOY. Measurement of both NO2 and NOY will be based on their conversion to NO, followed by detection of NO using the proven chemiluminescence technique. The NO2 conversion will use a photolytic technique in which NO2 is dissociated into NO + O by the action of a high-intensity photolysis lamp. The NOY conversion will take place on a heated catalytic surface, either molybdenum or gold in the presence of carbon monoxide. The existing NO system will be duplicated so that simultaneous measurements of NO and NO2 can be made.

Solar Terrestrial and Astrophysics SR&T

W88-70284 **188-38-01**
Goddard Space Flight Center, Greenbelt, Md.
SOLAR PHYSICS DATA ANALYSIS AND OPERATIONS
Stuart D. Jordan 301-286-8811

The objectives of this RTOP are: (1) to process, analyze, and interpret solar data from flight projects and to continue this work after the initial funding from project offices has been terminated; (2) to publish in the scientific literature detailed studies of phenomena gathered over protracted periods of time which reveal long term features and correlation effects not evident during the prime data analysis; (3) to engage in multi-disciplinary studies comparing experimental data from other satellites and/or ground-based laboratories in order to conduct detailed investigations of fine structure and long term and secular effects; and (4) to provide additional reduced and analyzed data for archiving in the National Space Science Data Center. During the prime analysis period, many theoretical ideas about the observed phenomena are developed and correlation of the data with other ground-based or satellite data are suggested. In addition, to study a given phenomenon over an adequate range of the important independent variables such as solar region, wavelength, solar cycle, etc., it is necessary to process large quantities of data covering extended periods of time. Thus, additional data will be processed and analyzed, multi-experiment studies will be made, and various proposed models or theories will be critically tested by use of these data.

W88-70285 **188-38-51**
Goddard Space Flight Center, Greenbelt, Md.
DEVELOPMENT OF SOLAR EXPERIMENTS AND HARDWARE
Stuart D. Jordan 301-286-8811

The objective of this RTOP is to develop scientific instruments which contribute to the solution of well-defined solar research problems. The planned research programs have the ultimate objective of flying payloads on problem-oriented missions. They will form the basis for future missions using the Shuttle or free-flyers. One of the programs will be a study of coronal structures contributing to the solar wind and the interplanetary plasma, a second will be a study of the sources of high-energy solar flare particles, and a third will study solar pulsations with a view to better understanding the solar interior. The instruments considered for these payloads are: (1) extreme ultraviolet (EUV) and soft X-ray spectroheliographs for observations of structures in the corona and active regions with 1 arcsecond spatial resolution and spectral resolution down to 10 m angstroms; (2) high-resolution telescope for measuring the spatial, spectral, and temporal characteristics of hard X-ray and gamma-ray emission from solar flares; and (3) a Solar Disk Sextant (SDS) to make high precision measurements of the solar diameter. In support of the programs for instrument development is the investigation of critical optical

components for ultraviolet and soft X-ray studies. This covers the design, fabrication, and testing of aspherical optical surfaces for Wolter Type-2 grazing-incidence telescopes. Also included are extended definition studies for future solar instrumentation and evaluation of new optical and detector technologies that may be applicable to future solar EUV and X-ray observations.

W88-70286 **188-38-52**
Goddard Space Flight Center, Greenbelt, Md.
GROUND-BASED OBSERVATIONS OF THE SUN
Stuart D. Jordan 301-286-8811

The first major objective of this program is to obtain and analyze observations of solar velocity and magnetic fields, global oscillations and wave motions, coronal holes, active regions, and flares at wavelengths observable from the ground. These observations complement ultraviolet (UV), extreme ultraviolet (EUV), X-ray, and gamma-ray observations made from NASA spacecraft such as the Solar Maximum Mission (SMM). Other objectives include: (1) to support operational planning for spacecraft experiments; (2) to conduct basic research and develop specific instrumentation and observational programs relevant to objectives for future flight missions; (3) to analyze comet tail photographs to determine the velocity field of the solar wind and the three-dimensional structure of interplanetary sector boundaries caused by the solar magnetic field; and (4) to study the plasma structure apparent in wide-field photographs of comets Giacobini-Zinner and Halley in the context of results obtained in situ by the International Cometary Explorer (ICE) and by the suite of Halley probes.

W88-70287 **188-38-52**
Marshall Space Flight Center, Huntsville, Ala.
RESEARCH IN SOLAR VECTOR MAGNETIC FIELDS
M. J. Hagyard 205-544-7612
(188-38-53)

The objective of this research is a program of ground-based observations for basic research concerning solar vector magnetic fields and for support of NASA solar missions using the facilities of the Marshall Space Flight Center (MSFC) Solar Observatory. In the program of basic research, theoretical and observational programs are undertaken to study vector magnetic field structures which are relevant to current problems in solar physics. To support future NASA solar programs, techniques of observation and of data reduction and analysis are developed using the MSFC vector magnetograph. Such techniques will generate guidelines for operations of planned space-based magnetographs, and will provide more focussed direction for the research performed with these instruments. Support of ongoing NASA solar missions is provided through daily observations, transmission of magnetograms to principal investigators (PI's) and other relevant personnel, and coordinated observing programs associated with collaborative investigations with mission PI's.

W88-70288 **188-38-53**
Marshall Space Flight Center, Huntsville, Ala.
STRUCTURE AND EVOLUTION OF SOLAR MAGNETIC FIELDS
R. L. Moore 205-544-7613
(188-38-52)

The general objective is to determine and understand basic empirical properties of solar magnetic fields, their effects in the solar atmosphere, and their generation within the sun. The general approach is to analyze Marshall Space Flight Center (MSFC) vector magnetograms along with complementary data from solar space missions and from ground-based observatories, and to interpret observed effects with physical models. The results will guide choices of specific observing programs for future solar space missions, including Solar-A, the X-ray ultraviolet (XUV) XUV spectrometer/imager on the Solar and Heliospheric Observatory (SOHO), and HSRO--the revised Solar Optical Telescope. We will pursue the following active region studies: (1) form and action of the magnetic field in flares; (2) non-potential magnetic features, their formation, and their relation to enhanced heating and flaring; (3) emergence and submergence of magnetic flux; and (4) magnetic structure, heating, and dynamic phenomena in sunspots. Quiet region studies will cover transition-region bright points and microflares and structure of the magnetic network and implications for the heating of the transition region and corona. Solar cycle studies will cover evidence in the sunspot record for bimodality of the solar dynamo, and X-ray bright points and fine-scale flux emergence.

W88-70289 **188-38-53**
Marshall Space Flight Center, Huntsville, Ala.
MHD STUDIES IN SPACE PLASMA THEORY: P-MODES, CORONAL, AND INTERPLANETARY DYNAMICS
S. T. Suess 205-544-7611
(442-36-55)

Analytical and numerical models are used to study solar magnetic fields and their extension into the corona and interplanetary medium. Specifically, we will study: (1) the formation, structure, and eruption of solar prominences as a source of coronal mass ejections; (2) the structure and evolution of magnetic clouds and the physical connection between clouds; (3) coronal mass ejections, and erupting prominences that cause clouds; (4) generation of flux tube waves and p-modes in the solar convection zone; and (5) the decay of flux tube waves in the corona and consequent coronal heating. We will also analyze the topology and fine-scale structure of the heliospheric current sheet, developing a theory for surface waves on the current sheet that incorporates the observed structure of the interplanetary magnetic field within the current sheet. The research on waves, however, has much broader application. The same theoretical construct will be used in the analysis of the decay of surface waves in the corona, which has been invoked as a coronal heating mechanism. Numerical calculations will be made on MSFC computers and elsewhere. Data sources include the Solar Maximum Mission (SMM), the Marshall Space Flight Center (MSFC) vector magnetograph, Ulysses (after launch), Helios 1 and 2, and Stanford's Wilcox Solar Observatory. The former title of this RTOP was Modeling Coronal Structures and Energetics.

W88-70290 **188-38-53**
Goddard Space Flight Center, Greenbelt, Md.
EXPERIMENT DEVELOPMENT: LABORATORY FOR THEORETICAL SOLAR PHYSICS
Stuart D. Jordan 301-286-8811

The primary objective of this RTOP is to support the laboratory's on-going programs by developing techniques for the interpretation of solar data. One specific goal is to correctly interpret the nature of observable solar phenomena by understanding the fundamental spectroscopic processes. In this regard, we will focus on the calculation of atomic transition probabilities and studies of atomic collision processes in solar plasmas. A second specific goal is to understand the flow of mass, energy, and momentum from a mechanical energy reservoir such as the convection zone to the chromosphere and corona. We will focus on the following areas: (1) the conversion of mechanical energy associated with the photospheric velocity fields into a nonthermal energy flux; (2) the propagation of this nonthermal energy from its point of generation within the photosphere to the chromosphere and corona; (3) the irreversible conversion of this energy into thermodynamic end products within the chromosphere and corona; (4) the nuclear processes occurring in solar flares as revealed in the gamma-ray spectrum; and (5) the consolidation of the above process (1 to 4) into models that predict new solar phenomena and explain those already observed.

W88-70291 **188-41-03**
Goddard Space Flight Center, Greenbelt, Md.
EMISSION LINE DIFFERENTIAL IMAGING CAMERA
Bruce E. Woodgate 301-286-5401

We plan a combined program of instrument development and use of those instruments on ground-based telescopes for uniquely sensitive narrow-band emission-line astronomy, to complement and prepare for space missions. By combining existing components such as a charge coupled device (CCD) camera, Fabry-Perot

interferometer, Lyot filter and microVAX controller into a differencing narrow-band imaging system, we will detect new emission-line emitting objects, and probe new temperature regimes of known objects. Scientific targets include cooling flows in clusters of galaxies, galaxy haloes, active galaxies, emission counterparts of quasi-stellar object (QSO) absorption features, supernova remnants, planetary nebulae to measure H(O), and an all-sky survey. Further instrument development includes use of a large-format CCD detector system, and construction of a nebular spectrometer, using grating technology planned for space use.

W88-70292 **188-41-21**
Goddard Space Flight Center, Greenbelt, Md.
GROUND-BASED ASTRONOMY
Jan M. Hollis 301-286-7591

The objective is to pursue a long range program in astronomical ground-based research in order that laboratory scientists remain current with state-of-the-art ground-based instrumentation and science that will provide impetus for future space-borne instrumentation and missions. This approach includes the use of ground-based instrumentation available at national research centers, such as Kitt Peak National Observatory and the National Radio Astronomy Observatory, in order to obtain data on a wide variety of astronomical sources such as the emission properties of peculiar stars and interacting binaries, radio interstellar medium studies, observations of active galaxies, and supernova remnants. Further, the approach extends to developing ground-based instrumentation for an existing observatory at the Goddard Space Flight Center (GSFC). This development will support potential future space applications as appropriate, in addition to supporting the development and evaluation of detector systems which are candidates for space flight as they are funded from other RTOPS or the GSFC director's discretionary fund. For example, the discretionary fund has recently provided for development of an advanced Lyot wide-field filter system for astronomical surveys.

W88-70293 **188-41-23**
Goddard Space Flight Center, Greenbelt, Md.
OPTICAL TECHNOLOGY FOR SPACE ASTRONOMY
Theodore R. Gull 301-286-6184

Space based instrument systems for astronomy afford scientists important advantages which cannot be fully utilized with ground based optical technology. In space, optical systems escape the detrimental atmospheric effects such as absorption and turbulence. This allows observations in previously inaccessible spectral ranges and the potential to measure ultra-faint and ultra-small objects. However, the technologies for space optics are fundamentally different from those for ground based systems. Technology developments for space optics specifically must address the expanded spectral region (X-rays to far-infrared), the vacuum environment, zero gravity, contamination, radiation damage, and the severe weight and volume constraints placed on payloads. The objective of this research and technology program, therefore, is to conduct investigations in those technology areas generic to the development of astronomy instrumentation for space. Relevant technical areas include optical system design and analysis, optical materials, optical fabrication, optical testing, mirror technology, and diffraction grating technology. We are presently conducting investigations in two technical areas that will have substantive cost/performance pay-offs. In optical materials research, we have placed major emphasis on ultraviolet mirror coating developments that will have an impact on improved system throughput. In the area of diffraction grating technology, we are conducting studies of advanced design, fabrication, and testing methods. Specific applications include high and low resolution spectrographs and imaging spectrometers for the ultraviolet and extreme ultraviolet.

W88-70294 **188-41-24**
Goddard Space Flight Center, Greenbelt, Md.
ULTRAVIOLET DETECTOR DEVELOPMENT
Andrew M. Smith 301-286-8648

The objective of this RTOP is the development of photon-counting detectors suitable for future space astronomy missions such as Lyman, second generation space telescope (ST) instrumentation, the Ultraviolet Imaging Telescope on Astro and various other Shuttle payloads. The detectors will be sensitive to far ultraviolet wavelengths, have a large format and high resolution. An in-house effort will continue to develop an intensified charge coupled device (CCD) detector consisting of a microchannel plate (MCP) intensifier coupled to CCD arrays with fiber optics. Additionally, methods of ultraviolet (UV) enhancement of CCD arrays by ion-implantation will be utilized by Tektronix, Inc. in fabricating CCD arrays which will subsequently be tested at the Naval Research Laboratory (NRL) and Goddard Space Flight Center (GSFC). Finally, work at Stanford University under Dr. Gethyn Timothy will be directed to improving the readout method of the Multi-Anode-Microchannel Array (MAMA) detector.

W88-70295 **188-41-51**
Goddard Space Flight Center, Greenbelt, Md.
UV ASTRONOMY AND DATA SYSTEMS
J. M. Mead 301-286-8543
(188-41-21)

The objectives of this RTOP are to perform theoretical and observational astronomical research of particular interest for space observations; and to develop tools and techniques which will facilitate and improve the reduction, analysis and understanding of astronomical data, primarily through the application of computers for managing large blocks of bibliographical and observational information, including digitized images and spectra, obtained at all wavelengths for stars, galaxies and other extended objects. The approach will involve stellar evolution calculations, quasar observations analyzed for comparison with theory, and observation with the International Ultraviolet Explorer (IUE) to extend knowledge of astrophysical plasmas. The existing machine-readable data base will be expanded by searching the journal literature, particularly in the infrared (IR) and ultraviolet (UV), to obtain more complete data and bibliographical coverage; and by installing data sets particularly tailored to IR searches and use of Infrared Astronomy Satellite (IRAS) data. Development of a Computerized Astronomical Data Retrieval System, with associated software, will continue, in order to produce data searches, plots, and bibliographical information for specified catalog identification numbers, positions and other parameters at all wavelengths. An Interactive Astronomical Data Analysis Facility, will be operated in order to provide astronomers with the display, enhancement and analysis tools they need to interpret digitized images and spectra.

W88-70296 **188-41-53**
Ames Research Center, Moffett Field, Calif.
THEORETICAL STUDIES OF GALAXIES, THE INTERSTELLAR MEDIUM, MOLECULAR CLOUDS, STAR FORMATION
B. F. Smith 415-694-5515

The objective of this RTOP is to conduct theoretical studies on: (1) fundamental phenomena associated with continuum spectra, dynamics and line spectra in active galactic nuclei; (2) the formation and evolution of galaxies and clusters, molecular cloud formation and evolution, and star formation; and (3) infrared emission in interstellar shocks. A large fraction of this effort involves computational astrophysics employing a wide variety of numerical codes developed at Ames to treat multidimensional hydrodynamic and magnetohydrodynamic fluid problems, with multidimensional particle problems, and complex radiative transfer problems.

W88-70297 **188-41-55**
Goddard Space Flight Center, Greenbelt, Md.
INFRARED AND SUB-MILLIMETER ASTRONOMY
M. G. Hauser 301-286-8679

The scientific objective of this program is to provide better understanding of the current state and evolution of astronomical objects. This is achieved by making observations at wavelengths from 1 micrometer to 1 mm and at spectral resolving power (lambda/(delta lambda)) from 1 to 10 to the seventh power. Since atmospheric opacity and emissivity prohibit or severly limit ground-based observations at certain wavelengths (e.g., 4 to 8

micrometers and 13 to 700 micrometers), high altitude observational platforms such as the Kuiper Airborne Observatory, balloons, or satellites must be used. High sensitivity composite bolometers are being developed in the far infrared to take maximum advantage of low background conditions achievable at these altitudes. A balloon-borne 1.5 m telescope is used to measure the small-scale anisotropy of the cosmic background radiation. An infrared sky camera is also used to image efficiently various sources. Infrared and sub-millimeter coherent (heterodyne) and incoherent spectrometers are developed and used to detect and resolve intensity profiles for neutral and ionized molecular and atomic lines. Correlative studies are made when possible to enable maximum insight into the physics of the medium. Laboratory studies of sample materials enhance ability to interpret astronomical observations of the interstellar medium.

W88-70298 **188-41-57**
Ames Research Center, Moffett Field, Calif.
LABORATORY STUDY OF CHEMICAL AND PHYSICAL PROPERTIES OF INTERSTELLAR PAHS
L. J. Allamandola 415-694-6890

It has recently been proposed that free molecular sized, polycyclic aromatic hydrocarbons (PAHs) are surprisingly abundant in many different astronomical objects and thus a widespread, but previously unrecognized, component of the interstellar medium which could play a dramatic role in many processes such as energy balance, molecular cloud collapse and dust particle formation. Testing of this hypothesis and its impact on the larger astrophysical picture is severely hampered by a general lack of knowledge of the spectroscopic, physical and chemical properties of PAHs in the forms they are likely to be in space: ions, radicals, neutral species and clusters. Spectroscopic properties of these unique species are particularly important to know since virtually all observational data pertaining to this problem is spectroscopic in nature. The major goal of this research is to provide the data necessary to test the PAH hypothesis and further our understanding of their potential role in astrophysics. Experiments will be performed in the laboratory in which the PAHs to be studied are prepared under conditions which duplicate, as much as possible, the interstellar conditions in which they are found. A special laboratory is being prepared to aid in getting best possible test results.

W88-70299 **188-46-01**
Goddard Space Flight Center, Greenbelt, Md.
HIGH ENERGY ASTROPHYSICS: DATA ANALYSIS, INTERPRETATION AND THEORETICAL STUDIES
Stephen S. Holt 301-286-8801

This RTOP is to support laboratory efforts at processing, analyzing and interpreting the data involving correlative studies from a variety of spaceflight experiments, and to conduct theoretical studies to support this effort. These theoretical and interpretive studies lead to the publication of results in the scientific literature and help in the planning of new missions in the areas of X-ray and gamma ray astronomies, energetic particle or cosmic ray astrophysics, and cosmological studies. The approach involves use of multisatellite data sets such as Voyager, Pioneer, Explorer (IMP), and Helios data for cosmic ray studies and Ariel 5, Orbiting Solar Observatory 8 (OSO-8), High Energy Astronomy Observatory 1 (HEAO-1) and Einstein for X-ray astronomy; and comparisons with data from other observatories, both space and ground based, at other wavelengths. A strong emphasis is placed on creating the theoretical framework for interpreting the results. This RTOP supports graduate student thesis research, research associates and occasionally a senior faculty member on leave from an academic institution. As an example, in the X-ray area we will follow-up on the discovery of new temporal and spectral phenomena in sources. The data bases span 5 years and offer complementary information on the variability of sources on time scales of milliseconds to years and spectra from 0.5 keV up to 10 MeV. We plan to emphasize spectral-temporal correlations best studied with multiple observations, to study models recommended by recent theoretical work and observations at other wavelengths, and studies which could be followed up by future missions such as the X-ray Timing Explorer (XTE).

W88-70300 **188-46-01**
Ames Research Center, Moffett Field, Calif.
THEORETICAL STUDIES OF ACTIVE GALAXIES AND QUASI-STELLAR OBJECTS (QSOS)
L. J. Caroff 415-694-5523

This research effort seeks to understand the origin of the continuum spectra of quasi-stellar objects (QSOs) and other compact luminous objects. An optically thick, relativistic outflow is postulated to arise in the central core of these objects and arbitrary input energy spectrum of photons and/or electron-positron pairs is assumed. The evolution of the energy distribution functions of the photons and pairs is followed until either the system becomes optically thin or thermal equilibrium sets in. At that time the emerging spectra are compared with observations. Interaction processes which are likely to be important to the spectral evolution are: pair-production, annihilation, Compton scattering, Bremsstrahlung, Coulomb scattering, and, if a magnetic field is present, synchrotron/cyclotron emission.

W88-70301 **188-46-56**
Goddard Space Flight Center, Greenbelt, Md.
PARTICLE ASTROPHYSICS AND EXPERIMENT DEFINITION STUDIES
J. F. Ormes 301-286-5705

The objective is to study the properties of the cosmic radiation in order to understand its origin and propagation, and to study the properties of the sites in which element synthesis and acceleration take place. The particles observed are the nuclear and electronic species of the cosmic ray particles: their energy spectra, their charge and isotopic composition, and their distribution in space. Some of these objectives can be met through the imaginative use of short duration observations on balloons. Experiments which must be outside the magnetosphere can be done on Explorer class spacecraft. Many heavier, larger-area payloads will require a large space platform. The space station will be an ideal platform and the presence of people to service, repair, and construct experiments in space opens exciting new possibilities. Supporting these objectives is both the development of new detector systems for measuring the elemental charge and isotopic composition of solar and galactic cosmic rays and associated theoretical studies relating to the sites, origin, models for acceleration, and mechanisms for particles transport. The emphasis will be on precise measurements of isotopic abundances of galactic cosmic rays, on new measurements of cosmic ray antiprotons, and the development of experiments for superconducting magnet spectrometer facilities for balloons and the space station.

W88-70302 **188-46-57**
Marshall Space Flight Center, Huntsville, Ala.
GAMMA-RAY ASTRONOMY
G. J. Fishman 205-544-7691

An observational program in gamma-ray astronomy is being pursued using balloon-borne experiments. Techniques and instrumentation for future space flight experiments are developed concurrently. The following are the objectives of the Marshall Space Flight Center (MSFC) research program: (1) to perform new scientific observations in gamma-ray astronomy using balloon-borne detectors; (2) to develop new detectors and experimental techniques for future space-borne gamma-ray astronomy observations; and (3) to study various sources of background radiation, primarily atmospheric gamma-ray radiation and activation of detectors and materials in order to increase the sensitivity of gamma-ray observations.

W88-70303 **188-46-57**
Goddard Space Flight Center, Greenbelt, Md.
GAMMA RAY ASTRONOMY
Carl E. Fichtel 301-286-6281

The technical objective is to develop the most appropriate

detector systems for the observation of astrophysical sources of very energetic photons. The first approach was the development of a large high energy telescope using digitized spark chambers. Many major improvements to this basic telescope system are still being pursued and other approaches to detector systems are now being developed for high energy, intermediate energy, and low energy gamma ray observations. In the high energy region improvements in the track imaging chamber systems are continuing, and special attention in the track imaging chamber research is now being directed towards drift chambers. At the same time, several approaches are being explored to improve angular resolution, including techniques to concentrate on higher energy photons. Improved attitude and aspect systems are being built. In the 1/2 to 40 MeV region different interaction processes become dominant and hence, new detector techniques are required. A totally new detector has been developed based on the Compton interaction process, but including several new concepts which together should increase the sensitivity by a factor of ten. For gamma ray burst studies new detector systems are being developed both for the gamma ray energy range and for detection of other wavelengths. In particular a ground-based system is being developed to detect and precisely locate optical flashes that are likely to occur in coincidence with gamma ray bursts.

W88-70304 **188-46-58**
Goddard Space Flight Center, Greenbelt, Md.
GAMMA RAY SPECTROSCOPY
Bonnard J. Teegarden 301-286-5277

The objectives of this effort are to develop new instrumentation to perform high resolution spectroscopy and imaging celestial gamma-rays in the 0.01 to 10 MeV range and to fly this instrumentation on high altitude balloons to assess the performance in a space-like environment and to gather scientifically meaningful data. In particular, the instrumentation will be designed to search for and measure the properties of narrow lines in the celestial gamma-ray spectrum. A major goal of this work will be the demonstration of new ideas and techniques for the eventual use in a satellite-borne experiment. The approach will center on the use of high purity germanium detectors to perform the most precise possible measurements of the gamma-ray energy. In addition, new techniques will be explored to further suppress instrumental background and thereby improve the sensitivity of the experiment. Finally, new methods will be explored for constructing images of the gamma-ray sky with an accompanying improvement in angular resolution over earlier experiments.

W88-70305 **188-46-59**
Marshall Space Flight Center, Huntsville, Ala.
TECHNIQUES FOR MEASUREMENT OF COSMIC RAY COMPOSITION AND SPECTRUM
T. A. Parnell 205-544-7690

An observational program to study cosmic ray composition, spectra, and interactions in the region 10 to the 12th power to 10 to the 14th power eV is being pursued with balloon-borne instruments in collaboration with the Japanese-American Cooperative Emulsion Experiments (JACEE) team. Techniques for extending measurements to the 10 to the 14th power to 10 to the 16th power eV region with future long-duration balloon and space flight experiments are being developed. In addition to analysis of data from previous balloon flights, the following studies are in progress at Marshall Space Flight Center (MSFC): (1) develop a technique for the estimation of heavy nucleus energy above 10 to the 14th power eV by measurement of linear frequency of Coulomb electron pairs in track emulsions; (2) develop efficient three-dimensional hadronic-electromagnetic cascade simulation of X-ray film spots and apply the simulations and scanning microdensitometry to primary energy and produced particle transverse momentum measurements; and (3) investigate the background in emulsions and X-ray films induced by the ambient space radiation.

W88-70306 **188-46-59**
Goddard Space Flight Center, Greenbelt, Md.
X-RAY ASTRONOMY
E. A. Boldt 301-286-5853

Celestial X-ray sources have introduced us to rich new aspects of astronomy ranging from the millisecond bursts of hard X-rays coming from the innermost orbits of matter falling into a black hole to the diffuse emission from extensive hot plasmas associated with clusters of galaxies. The combination of large sensitive area, low detector background, high temporal resolution and energy-dispersive spectroscopy over a broad band-width has been our approach in discovering and exploring these phenomena. The power of this approach has been well demonstrated. Extending it with improved spectral resolution and broad-band imaging is a major area of development now indicated. This involves the creation and evaluation of new systems incorporating low noise detectors of optimum energy resolution, large area X-ray concentrators and imaging devices.

W88-70307 **188-48-52**
Ames Research Center, Moffett Field, Calif.
CENTER FOR STAR FORMATION STUDIES
D. J. Hollenbach 415-694-4164

The general objective of the proposed research is to undertake a unified theoretical analysis of the problem of star formation. Solid achievement is likely to come, however, only with a healthy awareness of constraints placed on theoretical ideas by the ever increasing data base. Moreover, the interrelated theoretical problems cannot be attacked in isolation, but must be approached from the viewpoint of overall consistency with advances in other fields. Our comprehensive investigation includes: (1) studies of patterns of star-forming regions on galaxy wide scales; (2) dynamics, structure, energetics, and chemistry of the interstellar medium; (3) details of the fragmentation of molecular clouds and gravitational collapse of their dense rotating cores; (4) possible differences in the formation of high and low mass stars; (5) formation and evolution of protostars and nebular disks; (6) mechanisms of planetary system formation and disk dispersal; and (7) the origin of bipolar flows and their effect on the surrounding gas and dust.

W88-70308 **188-78-01**
Marshall Space Flight Center, Huntsville, Ala.
ADVANCED X-RAY ASTROPHYSICS FACILITY (AXAF)
D. C. Cramblit 205-544-0569

AXAF is a free-flying observatory featuring a high performance X-ray telescope for use over a 15-year lifetime through servicing from space station or Space Transportation System (STS) revisits. AXAF is now in the definition phase, aimed at long lead item development start efforts in FY88 and a launch in the 1994 to 1995 time period. Due in part to advances in metrology and fabrication technology in X-ray optics, AXAF is expected to be 50 to 100 times as sensitive as its predecessor, High Energy Astronomy Observatory 2 (HEAO-2). An ongoing technology mirror assembly program has already demonstrated the achievability of nearly all the AXAF optic goals. This RTOP activity will continue to place emphasis on the early development and demonstration of all science instrument and optics technologies critical to achieving AXAF science objectives and assuring a sound basis for program new start readiness in FY89.

W88-70309 **188-78-46**
Goddard Space Flight Center, Greenbelt, Md.
SMALL ATTACHED PAYLOADS FOR SPACE STATION
William D. Hibbard 301-286-7510

The objective of this RTOP is to assess the opportunities for small attached payloads to perform astrophysics and astronomy research on the National Aeronautics and Space Administration Space Station and to establish criteria for selecting and defining such experiments. The approach will be to convene a working group of scientists representing the various potential experiment disciplines. NASA Headquarters has received a group of proposals for small attached payloads. The working group will assess the

opportunities and requirements for accommodating these and similar payloads on the Space Station. A report will be published by the working group in 1988. RTOP activities will be completed by FY89.

W88-70310 **188-78-46**
Goddard Space Flight Center, Greenbelt, Md.
PARTICLE ASTROPHYSICS MAGNET FACILITY
William D. Hibbard 301-286-7510

The objective of this RTOP is to provide science support, system planning and a conceptual engineering design for a superconducting magnetic spectrometer, tentatively called the Particle Astrophysics Magnetic Spectrometer Facility (Astromag), that will fly as an attached payload on the Space Station. It will permit study of the properties of cosmic rays in order to understand their history as a sample of non-solar material, and their nucleosynthesis, acceleration, and transport in and effects on the galactic magnetic fields. It will also permit studies of the antiprotons observed recently in cosmic rays, and undertake antimatter searches 100 to 1000 times more sensitive than previously possible. Astromag will be designed for space servicing, including maintenance, cryogen resupply and exchange of experiment instrumentation. The approach is to conduct preliminary design trade-off studies leading to a feasible, economical facility concept. The studies will be carried out by the Particle Astrophysics Magnetic Facility Definition Team (Astromag Definition Team, or ADT), supplemented by the Goddard Space Flight Center (GSFC) Advanced Missions Analysis Office. The products will be reliable cost and schedule estimates, risk assessments, feasibility demonstration and the identification of long lead items, safety concerns and reliability approaches.

W88-70311 **188-78-62**
Marshall Space Flight Center, Huntsville, Ala.
GRAVITY PROBE-B
Rein Ise 205-544-1962

Gravity Probe-B is a free flying spacecraft which will confirm Einstein's General Theory of Relativity by measuring the relativistic precession of ultra precise gyroscopes. The project involves complementary activities at Stanford University and the Marshall Space Flight Center. The work is a coordinated theoretical, experimental, engineering project with MSFC having overall project management responsibility. Drawing on a broad experience base consisting of technology development, definition studies, tests, and analyses, a contract with Stanford University for the initial Engineering Development phase was signed in March 1985 and then in February 1987 the contract was extended to include the First Integrated System Test (FIST) to accomplish a ground demonstration of the complete system design. The engineering development will culminate in the launch of a Shuttle flight test experiment in FY92 and the beginning of the Science Mission development planned for FY90.

W88-70312 **188-80-02**
Goddard Inst. for Space Studies, New York, N.Y.
RESEARCH IN ASTROPHYSICS: SOLAR SYSTEM, TURBULENCE
Vittorio Canuto 212-678-5571

The objectives of this program are the study of the phenomenon of Large Scale Turbulence (LST) and its implications in astrophysics. The great diversity of physical settings (geophysics, atmospheric physics, origin of planets, accretion disks in general, molecular clouds, etc.) in which a detailed knowledge of turbulence is needed, is in stark contrast with the lack of an analytical model sufficiently general to be applicable to the above cases. Since the only available methods are either phenomenological expressions or numerical simulations of the full hydrodynamic equations, (neither of which is satisfactory), we have had as an objective that of constructing an analytical model for LST. The approach uses as the only ingredient for the energy source as well as for the cascade integral the growth rate of the unstable modes that ultimately generate turbulence. The results thus far fare very satisfactorily with a large variety of laboratory data.

Planetary Astronomy

W88-70313 **196-41-03**
Lyndon B. Johnson Space Center, Houston, Tex.
ATMOSPHERIC AND SURFACE COMPOSITIONAL STUDIES OF MERCURY
A. Potter 713-483-5061

The objective of this proposal is to study the composition of the atmosphere and regolith of the planet Mercury through spectral studies, and to apply the acquired knowledge to the understanding of the origin of the tenuous atmosphere and the history of the planet's origin and subsequent thermal evolution. This will include continued study of the spatial distribution of sodium and potassium across the planet. Measurements completed to date show considerable variations which are not understood. Models of the atmosphere will be constructed and tested against these observations. Spectroscopic measurements in the 8 to 13 micron band will be continued, provided that analysis of the spectra obtained this year, and now being reduced, show evidence of reststrahlen bands or the Christiansen peak.

W88-70314 **196-41-03**
Lyndon B. Johnson Space Center, Houston, Tex.
COMPOSITIONAL STUDIES OF PRIMITIVE ASTEROIDS
F. Vilas 713-483-5056

The objective of this proposal is to study the composition of the C, P, D, F (primitive) asteroids through the study of their spectral properties, and to apply the acquired knowledge to the understanding of the origin and history of these asteroids, and their possible links to other solar system objects. This will include a three-fold approach: (1) obtaining new narrowband charge coupled device (CCD) reflectance spectra of outer-belt and main-belt primitive asteroids in the 0.5 to 1.0 micron spectral range; (2) combining these new spectra with existing spectra of 34 primitive asteroids and examining them for fine absorption features seen near 0.6 to 0.7 microns in terrestrial clay silicates and carbonaceous chondrites attributed to iron oxides. If a statistically significant sample of spectra is obtained, a hypothesis proposing discrete remnants of a gradation in composition of asteroids retained in the outer solar system when other material was ejected from the earth's solar system will be tested; and (3) obtaining spectra in the 3.0 to 4.0 micron spectral range to search for a C-H stretch absorption seen in terrestrial organic polymers.

W88-70315 **196-41-30**
Marshall Space Flight Center, Huntsville, Ala.
INFRARED IMAGING OF COMETS
C. M. Telesco 205-544-7723

The objective of this RTOP is an observational program using detector array instruments for infrared imaging of comets. An existing infrared array camera containing 20 bolometer detectors will be used to study the large-scale spatial distribution of infrared emission in comets in the wavelength region from 10 micrometers to 30 micrometers. These observations will be performed from ground-based infrared observatories. An additional infrared system with an InSb detector array spanning the wavelength region 1 micrometer to 5 micrometers is now under development. Beginning in the second half of FY88, observations with this instrument will complement in an important way those obtained with the bolometer array.

W88-70316 **196-41-50**
Goddard Space Flight Center, Greenbelt, Md.
GROUND-BASED INFRARED ASTRONOMY
Donald E. Jennings 301-286-7701
(188-41-55; 154-50-80)

The scientific objective is to determine information on astrophysical objects, such as molecular clouds, interstellar lines, molecular and circumstellar components in stellar atmospheres, and planetary atmospheres from high spectral resolution

ground-based measurements in the intermediate infrared. A spectrometer system employing a cryogenic Michelson interferometer (77K) has been developed to meet the simultaneous requirements of high spectral resolution, a wide free spectral range and high sensitivity. An optical retardation up to 25 cm provides an unapodized spectral resolution up to .02/cm in the 400 to 2000/cm range. A post-dispersed detection system has been used to reduce background noise from a warm telescope and instrument system and the atmosphere at the detector, thus allowing the multiplex advantage of the interferometer to be retained. Cooled or warm Fourier transform spectroscopy (FTS) instrumentation with the post-dispersed detection system, operating at a favorable infrared site, allows maximum sensitivity to be attained at a ground-based site. The sensitivity level for a measurement in the 1000/cm region with a 122 cm diameter telescope, an integration time of 60 minutes and a spectral resolution of 0.2/cm is approximately 5/(10 to the 26th power) watts/square meter/Hz. The S/N level for Jupiter in the 1000 cm region is 7 for one minute integration time and full spectral resolution of 0.02 cm. Observations took place during December 1985, August 1986, and June 1987 with the post-dispersion system and the FTS at the Kitt Peak 4-m telescope.

W88-70317 **196-41-51**
Goddard Space Flight Center, Greenbelt, Md.
PASSIVE MICROWAVE REMOTE SENSING OF THE ASTEROIDS USING THE VLA
W. J. Webster, Jr. 301-286-4506

We intend to infer structure and composition parameters for a selected set of the ten physically largest asteroids by employing microwave remote sensing techniques originally developed for earth observations. Precise flux density measurements made with the Very Large Array (VLA) of the National Radio Astronomy Observatory will be used to define the microwave continuum spectra of these asteroids. These spectra will be inverted in order to estimate the near-surface bulk properties (radii, roughness, composition) independent of previous optical or infrared spectroscopy. Expected results include: (1) radio emission spectra spanning the widest range in wavelength for 1 Ceres, 2 Pallas, 4 Vesta and 10 Hygiea; (2) 2 cm observations of selected smaller asteroids; and (3) interpretation of the spectra by inversion techniques.

W88-70318 **196-41-52**
Goddard Space Flight Center, Greenbelt, Md.
IMAGING STUDIES OF COMETS
Malcolm B. Niedner, Jr. 301-286-5821

This RTOP provides for the operation of a small high altitude observatory, Joint Observatory for Cometary Research (JOCR). The imaging data obtained at JOCR are principally wide-field and address the interaction of bright comets with solar radiation and the solar wind. Research can be carried out with ground-based images alone, but if suitable data from spacecraft such as the Ulysses Mission, the International Cometary Explorer (ICE), or Halley deep-space probes are available, the ground-based images and in situ measurements are combined to provide sensitive information about the solar wind in three dimensions. Funding under this RTOP provides support for the operation of the observatory only; analysis of research results is funded by the interested program office. The observatory site in central New Mexico is one of the darkest sites left in the continental U.S. Extensive photography of approximately 10 bright comets since 1973, including recent comets Giacobini-Zinner and Halley, has been carried out. These photographs show extensive features in the plasma tail out to several tenths of a.u. from the head which can be analyzed for phase speed and lifetime, growth rate, etc. The results have served as diagnostics to the plasma and magnetic field environment of comets, including the magnetic field strength in the tail, the injection speed of ions into the tail, the pressure balance conditions, across the tail, etc. The sudden growth of a plasma tail in comet IRAS appears to have been caused by a very large X-class solar flare and a resultant sudden pulse of photoionization in the coma. Probably most spectacular, disconnection events (DEs) of the plasma tail were discovered in JOCR images of comet Kohoutek.

W88-70319 **196-41-54**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED INFRARED ASTRONOMY (TASK 01) AND SPECTROSCOPIC PLANETARY DETECTION (TASK 02)
M. J. Mumma 301-286-6994

The objectives of this RTOP are twofold. Task 01 studies the molecular constituents of solar system objects (e.g., planetary atmospheres and comets) through observations of their infrared (IR) line spectra. High spectral spatial resolution is utilized in order to obtain information on spatially localized phenomena and on dynamical processes (e.g., winds in planetary atmospheres). The approach is to develop and utilize laser heterodyne spectrometers for ultrahigh spectral resolution in the mid-infrared (8 to 30 micrometers), and to utilize Fourier transform instrumentation in the near infrared (lambda less than 8 micrometers). These techniques provide optimum sensitivity, resolution and spectral stability needed for problems such as mapping the excitation conditions and outflow velocities in cometary comae. Observations are conducted from ground-based observatories and from the Kuiper Airborne Observatory. Task 02 is directed towards extending our knowledge to planetary systems which may exist around other solar-type stars. The underlying principle is that such extra-solar planetary systems could be detected by measuring the small Doppler reflex which planetary orbital motion produces in the spectrum of the parent star. The objective of this task is to validate such an approach by measuring the velocity stability of integrated sunlight. Solar-cycle related effects which are observed are compared to the 13 m/sec Doppler reflex induced by the orbit of Jupiter, and prescriptions are developed for separating these effects so that planetary Doppler signatures can be identified in stellar spectra. In order to obtain great spectral stability, the observational approach is to use Fourier transform and laser heterodyne spectrometers in the infrared spectral region.

W88-70320 **196-41-67**
Ames Research Center, Moffett Field, Calif.
PLANETARY ASTRONOMY AND SUPPORTING LABORATORY
F. P. J. Valero 415-694-5510

The composition of planetary and cometary atmospheres and surfaces and the abundance, temperature and pressure of certain atmospheric constituents can be determined by spectroscopic observations from ground-based and airborne observations. Such data are necessary for the preparation of valid model atmospheres, which are needed to evaluate the possibilities of life on the planets, to design systems for exploratory missions and for the preparation of evolutionary models of planetary interiors. The objectives of this work are to obtain, study and analyze spectroscopic observations of comets, planets and their satellites; to obtain and analyze, in the laboratory, spectra appropriate for valid interpretation of the observations; and to develop the analytical and computational techniques necessary to interpret the observational spectra in terms of real planetary atmospheres and surfaces, and cometary gases and ices. The objective will be pursued in measuring, in the laboratory, basic molecular parameters such as basic band modeling parameters, absorption line half-widths, vibration-rotation interaction constants, and line pressure induced shifts and absorption in the gas phase as well as absorption band profiles and intensities for these molecules condensed as ices.

Life Sciences SR&T

W88-70321 **199-11-34**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ULTRASOUND DETECTION OF BENDS
J. A. Rooney 818-354-2503

The objective is the development of swept frequency ultrasonic techniques that are capable of quantifying the onset or development

of decompression sickness in NASA flight personnel. The specific objectives include: (1) development, characterization, and optimization of swept-frequency ultrasonic techniques utilizing transmission, reflection, harmonic and phase detection technologies to exploit resonant properties for quantification of bubbles in biological systems; (2) determination of the necessary design parameters for an ultrasonic system for imaging and quantifying bubble populations and dynamics; (3) determination of the acoustic parameters of bubbles in biological systems in the size range of interest to NASA investigators; (4) determination of the feasibility of utilizing swept-frequency ultrasonic systems for quantifying bubble dynamics and bubble population interactions; and (5) development, in collaboration with other NASA investigators, of the basic design criteria for ultrasonic techniques for use in studies and monitoring of decompression sickness. The objectives will be met by the modification and development of the unique Jet Propulsion Laboratory (JPL) swept-frequency ultrasound system. Transmission, reflection, harmonic, and phase-detection techniques will be developed and compared for sensitivity and resolution. Consultations and collaborations with investigators at the Johnson Space Center (JSC) will be developed and used to determine desired system parameters. Decompression sickness (DCS) following excursions in low atmospheric pressures, such as those associated with extra-vehicular activities (EVA) on space flights, is a cause for concern. If safe, soundly based EVA procedures are to be developed, it is necessary to have improved quantitative bubble detection and analysis techniques. With such a system, quantitative studies of EVA procedures, space suit evaluation, and monitoring of decompression sickness will become feasible.

W88-70322 **199-12-52**
Ames Research Center, Moffett Field, Calif.
SPACE ADAPTATION SYNDROME
J. Billingham 415-694-5181
(199-10-62)

This RTOP is managed by Johnson Space Center (JSC).

W88-70323 **199-21-12**
Ames Research Center, Moffett Field, Calif.
CARDIOVASCULAR PHYSIOLOGY
J. Billingham 415-694-5181

The overall goal of this program is an understanding of the cardiovascular fluid electrolyte changes occurring with spaceflight. Specific aims are to: (1) define underlying mechanisms; (2) determine whether specific cardiovascular risks occur with short and long term microgravity exposure; (3) develop and test appropriate models and countermeasures for observed changes; and (4) develop and implement appropriate spaceflight experiments. To accomplish this goal, ground-based studies on both human and animal subjects will be carried out. Specific activities will include: (1) determine effects of exercise training on deconditioning; (2) use exposure of humans to horizontal and head-down bed rest and water immersion to study mechanisms of deconditioning; and (3) test procedures, devices and drugs, including the use of so-called artificial gravity, to prevent and counteract deconditioning. Results should lead to a better understanding of mechanisms of cardiovascular deconditioning, better devices and procedures for modifying deconditioning effects, and specific spaceflight experiments. Results of proposed studies will improve flight safety and understanding of spaceflight risks. They will also provide access to flight of a broader segment of population, and will use weightlessness to expand our understanding of cardiovascular/fluid-electrolyte function and autonomic nervous system control of the cardiovascular system.

W88-70324 **199-22-22**
Ames Research Center, Moffett Field, Calif.
NEUROPHYSIOLOGY
N. G. Daunton 415-694-6245
(199-12-51)

Significant changes occur in the way the Central Nervous System (CNS) processes sensory inputs and programs motor outputs during adaptation to the micro-gravity environment of space, and during re-adaptation to earth's gravity. These changes in CNS processing result in space motion sickness, perceptual illusions, performance deficits, and postural control deficits, all of which impair the operational efficiency of astronauts, especially during the first three to five days of exposure to micro-gravity and re-exposure to earth's gravity. It is not known whether the changes in CNS structure and function will be reversible after long-term (years) exposure to micro-gravity. The overall objective of this program is to identify CNS components and mechanisms underlying the process of adaptation/re-adaptation to altered gravitational conditions so that the consequences of long-term, as well as short-term, exposures to micro-gravity on the CNS can be determined. The general approach to understanding these components and mechanisms involves identifying in both ground and flight investigations the functional changes which occur during adaptation to altered-gravity environments and then determining the neurophysiological, neurochemical, and structural changes in the CNS which underlie the functional changes. With this knowledge, countermeasures can be developed to minimize specific problems and to ensure productivity, health, and safety in space and on return to earth.

W88-70325 **199-22-32**
Ames Research Center, Moffett Field, Calif.
BONE PHYSIOLOGY
S. B. Arnaud 415-694-6561
(199-40-32)

The overall goal of the Bone Physiology Program is to advance our knowledge of the causes and mechanisms of the immediate and delayed effects of spaceflight on skeletal and calcium metabolism in man and animals in order to form a rational basis for their prevention. Short term goals are focused on one of the four recognized problems which occur during weightlessness: demineralization of bone. This may or may not be directly related to the other three documented changes in calcium metabolism in astronauts: negative calcium balance, modest increases in circulating calcium and phosphorus, and calciuria. Goals are approached through research projects, involving animal and human subjects. These emanate from a variety of disciplines in both basic science and clinical medicine. Every opportunity to coordinate studies with flight material is sought to validate ground-based human and animal models for weightlessness. These models can range from whole animals, immobilized to simulate hypogravity, to cell culture systems developed to pinpoint the cellular response to chemical or biochemical alterations in a space environment. These experiments form the data base for predicting the physiologic effects of long term spaceflight, and for developing the countermeasures needed to ensure the health and productivity of people who will reside in and travel to and from space.

W88-70326 **199-22-34**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
BONE LOSS
S. L. Manatt 818-354-4256

This program seeks to develop the best approaches and instruments for in vivo bone mineral measurements that best satisfy NASA's needs and to carry out studies of the extent and mechanism(s) of bone mineral changes due to zero-g and immobilization. This task consists of two components. The first is a research contract with the Medical School, University of California at San Francisco (UCSF), for development of a new type computer tomography (CT) system for bone mineral measurements, the testing of the latter instrument, and the delivery and installation of the latter at Johnson Space Center (JSC) at the beginning of FY88. A second component of this work involves studies with a small X-ray scanner at the Jet Propulsion Laboratory (JPL) with the capability for investigations, both in the CT and absorptiometry modes of operation, of phantoms and standard samples. These latter will be used in the test of accuracy and precision of the instrument being assembled at UCSF. The potential application of the small JPL scanner for small animal and plant material studies is being evaluated. Interest in these applications of this scanner

has been expressed by Livermore Lab., Los Alamos Lab., and Vestar Research, Inc. The potential of nuclear magnetic resonance (NMR) imaging and other NMR techniques for obtaining new fundamental information on bone mineral biochemistry will receive some consideration.

W88-70327 **199-22-42**
Ames Research Center, Moffett Field, Calif.
MUSCLE PHYSIOLOGY
R. E. Grindeland 415-694-5756
(199-40-32)

The overall aims of this research program are to determine the underlying causes for the muscle atrophy problem observed in both humans and animals in space, to adequately characterize the atrophy, and to develop suitable countermeasures. Specific objectives consist of: (1) determining the rate and extent of atrophy and recovery from atrophy; (2) conducting basic studies into the nature of the biochemical and physiological mechanisms which regulate skeletal muscle mass and function; (3) developing and validating methods for monitoring atrophy of skeletal muscle in human subjects and laboratory animals; and (4) finding possible countermeasures to forestall muscle atrophy. The nature, extent, and rate of atrophic muscle changes will be thoroughly characterized and the effects on muscular performance determined. Alterations in muscle physiology, biochemistry, electromyography, and neuromuscular functions will be studied. The rate and completeness of recovery from atrophy will also be investigated. Basic mechanisms underlying muscle atrophy will be investigated in terms of intramuscular and systemic biochemical factors regulating protein biosynthesis (initiation factors, prostaglandins, growth factors) and protein degradation. Methods for monitoring muscle atrophy by nuclear magnetic resonance spectral and image analysis will be studied. Specific exercise protocols, pharmacological agents, and electrical stimulation will be evaluated as countermeasures against atrophy.

W88-70328 **199-22-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MUSCLE PHYSIOLOGY
R. H. Selzer 818-354-5754
(199-21-14)

This task seeks to carry out research and development of magnetic resonance (MR) techniques that can be applied to areas connected with the NASA Life Sciences program. The task has two components: an instrumentation component involving implementation of a magnetic resonance imaging device at the Jet Propulsion Laboratory (JPL) that will serve as a test bed for the future design of a flight MR system and a human application component for development of computer methods to measure muscle mass from magnetic resonance images obtained with existing clinical magnetic resonance image (MRI) systems. The instrumentation component is described by Task 01 and the clinical applications by Task 02. Task 01 will involve development of new and better nuclear magnetic resonance (NMR) experimental procedures, achievement of better understanding of relation of basic NMR parameters to life processes, and development of NMR instrumentation that could be flown on a dedicated Life Sciences mission or early space station mission. Task 02 involves implementation of computer software to measure muscle volume from multiple cross-sectional MR images and determination of the accuracy and precision of the measurement and testing in animal models. The technique will be applicable to problems of evaluating muscle atrophy countermeasures and to the problem of pre- and post-flight monitoring of muscle atrophy of space station passengers.

W88-70329 **199-22-62**
Ames Research Center, Moffett Field, Calif.
CREW PRODUCTIVITY
H. Clayton Foushee 415-694-6114
(505-67-01; 506-47-11)

The general objectives of this RTOP are: (1) to develop better methodological approaches to the study of group process variables in naturalistic environments; (2) to achieve, through the use of these approaches, a better understanding of those factors which affect group function in space environments; (3) to identify and assist in the solution of current and future operationally significant group performance problems in aerospace environments; (4) to provide design guidelines for better crew reliability based upon aspects of selection, organization, and training; and (5) to track the impact of these approaches so that further improvement and understanding may be obtained. These general objectives are aimed at the production of practical guidelines for issues confronting the U.S. space program. Heretofore, group productivity research has been of little use because it has typically been conducted in sterile laboratory research environments that are not generalizable to aerospace operations. Moreover, the methods of analysis and performance criteria have had little to do with the conduct of meaningful work in challenging and often stressful environments. One of the strengths of the proposed research plan is that it is organized to integrate the best available theoretical and empirical laboratory work and to test these principles in the most high fidelity environments available. It is believed that the net effect will be knowledge that can be immediately utilized by space operations planners.

W88-70330 **199-22-74**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RADIATION EFFECTS AND PROTECTION
Gregory A. Nelson 818-354-4401

The objective of this RTOP is to delineate the genetic and developmental effects of heavy ion radiation similar to that found in space as cosmic ray or high-charge Z and E (HZE) particles. We are using the simple animal C. elegans as a model system in studies conducted at JPL and at the Lawrence Berkeley Laboratory Bevalac accelerator where accelerated ions of desired properties can be obtained. Cell survival and differentiation have been investigated using the development of a four-cell gonad primordium into a complex functioning adult structure. Autosomal, visible and lethal mutations, formation of nucleoplasmic bridges (produced by chromosomal rearrangements), and duplications of X chromosome segments are analyzed to understand ion-induced genetic lesions. The kinetics of production of these various lesions is being investigated as functions of particle fluence and linear energy transfer (LET). Relative biological effectiveness (RBE) versus LET relations have been described for several lesions. The structures of ion-induced mutants are under investigation and modification of kinetics is being tested in four radiation sensitive strains. The activities of DNA repair systems will be investigated by the isolation of additional radiation-sensitive mutants using transposon mutagenesis to facilitate identification of new genes and gene products. Characterization of ion-induced mutants in the unc-22 gene will be tested at the molecular level by hybridization of cloned unc-22 (+) DNA to mutant DNA processed with restriction endonucleases. Ion-induced lethal mutations in the eT1 balanced regions of chromosomes 3 and 5 are being analyzed by conventional crosses and deletion mapping to quantify the proportions of chromosomal rearrangements, deletions and point mutations.

W88-70331 **199-22-92**
Ames Research Center, Moffett Field, Calif.
VESTIBULAR RESEARCH FACILITY (VRF)
D. L. Tomko 415-694-5723
(199-22-22; 199-40-12)

The Vestibular Research Facility (VRF) provides unique research opportunities to scientists whose work requires delivery of precisely controlled, vibration-free rotational and linear acceleration stimuli alone, or during exposure to altered-g background stimulation. In the broadest sense, objectives of VRFs scientific research program are to: (1) conduct research on effects of precise rotational and linear accelerations on physiological mechanisms (e.g., vestibular system), during adaptation to altered background g levels provided by centrifugation; (2) define critical questions about vestibular function which require micro-gravity studies, and define methods to answer those questions; (3) facilitate

planning of neuroscience flight studies, provide required ground-based pilot studies, and enable pre- and post-flight testing; and (4) collect baseline data for flight experiments on motion sickness, and on vestibular or other nervous system functions affected by micro-g. The second facet of the VRF program is involved with hardware development. The objectives of this part of the program are to: (1) provide completed VRF hardware to support the science objectives; (2) complete VRF hardware which is under development; and (3) design and implement experiment specific hardware. Science objectives will be thus achieved by providing a unique facility which will serve as a focal point for involvement of university affiliated scientists, in-house scientists and engineers in performing experiments designed to support NASA's life science goals.

W88-70332 **199-30-32**
Ames Research Center, Moffett Field, Calif.
BIOSPHERIC MONITORING AND DISEASE PREDICTION
P. D. Sebesta 415-694-5232

The objective is to employ NASA-derived technologies to study and model the environmental parameters which influence the distribution and prevalence of vector-borne diseases. A series of NASA-sponsored workshops has identified malaria as the candidate disease. In situ studies will relate the environmental variables to the disease vector. These environmental variables will be studied by remotely sensed data. The relationship between remotely sensed data and vector population dynamics will be established and modeled. Modeling will be in the context of a Geographic Information System and used for purposes of predicting the temporal and spatial occurrence of vector populations and malarial transmission.

W88-70333 **199-30-32**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
BIOSPHERIC MONITORING AND DISEASE PREDICTION
J. F. Paris 818-354-6936

The objective is to further develop the understanding of the use of optical and active microwave sensors for the characterization of wetlands relative to studies of vector-borne diseases. The role of remote sensing in the research is to measure and to map the environmental conditions in vector habitats as they change through a season. These remotely sensed environmental conditions would then be used by public health scientists in a model to predict the progress of a vector-borne disease such as malaria. Our approach is to use the capabilities of optical sensors in responding to foliage amount and water background to monitor season changes in some vegetated wetlands (e.g., rice). Also, we would use the capability of active-microwave sensors to respond to vegetated wetlands and to the woody components of vegetation. The latter may be the sensor of choice due to the cloudiness of the tropical regions where the environmental assessments are desired. Our approach is to use existing sensors on trucks (Jet Propulsion Laboratory) and aircraft (DC-8, ER-2, and C-130) to study several wetland areas in the United States (Sacramento Valley, California and the Everglades, Florida). These existing sensor systems will have follow-on counterparts on the first European Remote Sensing (ERS-1) satellite and on the Earth Observation System (EOS) in the 1990s. Our work in FY88 and FY89 is to prepare for these spacecraft-based systems that may be used in the disease modeling work.

W88-70334 **199-30-62**
Ames Research Center, Moffett Field, Calif.
BIOGEOCHEMICAL RESEARCH IN TROPICAL ECOSYSTEMS
P. A. Matson 415-694-6884
(199-30-72; 677-21-31)

The objective of this research is to quantify fluxes of important biogenic gases from tropical ecosystems, and to understand the sources, sinks, and processes that control flux out of the systems. It will involve measuring emissions of nitrous oxide, non-methane hydrocarbons and other gases in a range of forests representing gradients of climate, fertility, and disturbance. The long-term goal of this project is to establish a geographic perspective on trace gas flux and biogeochemical processes in tropical environments. This encompasses measurement of gas fluxes from soil and vegetation and estimation of their importance over large areas.

W88-70335 **199-30-72**
Ames Research Center, Moffett Field, Calif.
BIOGEOCHEMICAL RESEARCH IN TEMPERATE ECOSYSTEMS
D. L. Peterson 415-694-5899
(677-21-35; 677-21-31)

The objectives are to: (1) characterize the pathways and measure the rates of biogeochemical cycling of carbon, nitrogen, phosphorus, and sulfur in temperate ecosystems; (2) model these processes; (3) identify and map through remote sensing key indices diagnostic of changes in element flux; and (4) examine consequences of various disturbance regimes on atmosphere-water-biosphere interaction. The approach is to: (1) develop a scientific logic and framework for organizing ecosystems on gradients, such as open to closed (high to low nutrient turnover); (2) identify and test key indices of ecosystem state on intact, artificially perturbed (fertilization, irrigation, etc.), and chronic (pollution) to abrupt (fire, harvesting, conversion) disturbance regimes which are predictive of element flux changes; and (3) develop a regional data base reflecting these principles and conduct trace gas and hydrologic nutrient movement studies and models at appropriate geographic scales.

W88-70336 **199-30-99**
Goddard Inst. for Space Studies, New York, N.Y.
REMOTE SENSING OF NATURAL WETLANDS
Inez Fung 212-678-5590

The objective of this RTOP is to explore the feasibility of monitoring the global seasonal distribution of natural wetlands by remote sensing techniques. Dr. B. Choudhury of Code 624 has obtained global distributions of the monthly brightness temperature from 1979 to 1984 from dual-polarized radiation at 37 GHz measured by the Scanning Multichannel Microwave Radiometer (SMMR) aboard Nimbus-7. The brightness temperature has been shown to be a good monitor of soil moisture as well as of vegetation dynamics. We propose to compare the distributions of brightness temperature with a global digital database of wetland ecosystems to explore the ability of the brightness temperature to distinguish natural wetlands. Also, the seasonality of the brightness temperature will be examined against field observations of flooding to test the validity of the timing and areas of seasonal inundation obtained from SMMR data.

W88-70337 **199-30-99**
Goddard Inst. for Space Studies, New York, N.Y.
GLOBAL MODELING OF THE BIOLOGIC SOURCES OF METHANE
Inez Fung 212-678-5590

The objectives of this RTOP are to: (1) obtain estimates of methane emission from natural wetlands on a global basis; (2) investigate seasonality of methane emission based on climate variations; and (3) verify estimates of emissions using a three-dimensional transport model and observations of atmospheric methane. A global model of seasonal emission of methane from natural wetlands will be developed. The model will account for the influence of wetland ecology and seasonal climate variations on the rates of methane emission. The emission model will be calibrated against field measurements of methane emissions, where such measurements exist. To validate the seasonal emission of methane on a global basis, the emission will be used as inputs to a three-dimensional atmospheric transport to simulate the variations of methane in the atmosphere. The comparison between the simulated and observed distributions of atmospheric methane will constrain the magnitudes and timing of the biospheric emissions.

W88-70338 **199-30-99**
Goddard Space Flight Center, Greenbelt, Md.
GLOBAL INVENTORY MONITORING AND MODELING EXPERIMENT
Compton J. Tucker 301-286-7122
(677-21-32)

The objective of this RTOP is to develop the techniques and scientific basis for studying terrestrial renewable resources at regional, continental, and global scales with multilevel satellite remote sensing data. Satellite data will be obtained at spatial resolutions of 30 m, 80 m, 1 km, 4 km and 15 km for selected local areas (30 and 80 m), regional test sites (1 km), continental test areas (4 and 8 km), and the entire planet (15 km). These data will be analyzed to provide high temporal frequency vegetation biomass and condition information for assessing productivity and other large-scale vegetation information of interest to global science questions such as the earth's radiation budget, biogeochemical cycles and the hydrological cycle. Specific studies will be undertaken for studying ecologically-coupled disease outbreaks in Africa. Expected results include: (1) the understanding of large-scale vegetation response and its relationships to atmospheric CO2 concentrations; (2) estimates of grassland biomass production across entire continental ecological zones; (3) improved documentation of forest spatial extent for selected tropical and boreal forests; and (4) comparisons between disease outbreaks of Rift Valley fever and vegetation dynamics from East Africa for the time period of 1980 to 1985.

W88-70339 **199-40-12**
Ames Research Center, Moffett Field, Calif.
GRAVITY-SENSING SYSTEMS
M. D. Ross 415-694-5757
(199-40-22; 199-40-32)

The long-term goal of this RTOP is to increase our understanding of information processing in animal linear bioaccelerometers, on Earth and in the microgravity of space. This represents a change in scope. Individual investigators will conduct their research on mechanisms underlying transduction, neural innervation patterns, physiological characteristics of nerve responses, and development of a functional linear bioaccelerometer as part of a team effort to understand how gravity-sensing end organs process information to make it useful for orientation of the whole organism in a gravitational field. Evolutionary aspects take on special significance in this setting, so that work on invertebrates is important. The ultimate goal is to produce working models of functioning gravity-sensing neural networks, to serve as tools to increase understanding. Goals can be achieved by focusing on certain critical questions. Initially, combined morphological and physiological studies are required, so that nerves of known response can be reconstructed as a partial basis for modeling. A further critical need is to know the response characteristics of type I and type II hair cells. Other information from pharmacological and biochemical research will help to fine-tune the models.

W88-70340 **199-40-22**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENTAL BIOLOGY
M. D. Ross 415-694-5757
(199-40-12; 199-40-32; 199-40-27)

Gravity has been an omnipresent force throughout the evolution of life on this planet. How it has influenced the evolutionary process and continues to impact the daily existence of life on this planet is largely unknown. The major objective of this research program is to further our understanding of the role and influence of gravity and the lack thereof on the processes of reproduction, growth, development and aging. Specific hypotheses currently under investigation include: (1) gravity is a determinant of pattern specification in amphibian and avian embryogenesis; (2) gravity is required for the normal development of the musculoskeletal, nervous, and other organ systems in mammals, amphibia, and echinoderms; (3) cytoskeletal formation is influenced by the gravity vector in a variety of vertebrate and invertebrate species; and (4) gravity plays an important role in the behavior and aging of poikilotherms. Ground-based studies using hyper-gravity (centrifuges) and gravity vector randomization (clinostats) are performed to develop techniques and baseline data in support of flight experiments. Spaceflight investigations are conducted aboard the Space Transportation System (STS)/Spacelab, Soviet Cosmos Biosatellites, and ultimately the Space Station.

W88-70341 **199-40-32**
Ames Research Center, Moffett Field, Calif.
BIOLOGICAL ADAPTATION: (A) STRUCTURE AND BIOMINERALIZATION; (B) REGULATORY MECHANISMS
E. M. Holton 415-694-5471
(199-40-12; 199-40-22)

All biological species on Earth have evolved under the influence of gravity. In response to this force, organisms have developed structures to withstand gravity loads and regulatory mechanisms which may be optimized for terrestrial gravity. The objectives of Structure and Biomineralization are: (1) to identify, compare and contrast structures that living systems have evolved in response to gravity and to understand the influence of gravity on regulation of size, shape, composition, maturation, metabolism, and function; (2) to elucidate whether gravity directly affects cells regulating structural mass and metabolism and/or exerts its effect extracellularly through local or systemic factors; (3) to determine the role and/or utilization of ions (e.g., calcium) in mediating gravitational responses resulting in gravity-dependent structure; and (4) to use microgravity as a tool to understand the role of gravity in evolution of structural elements. The objectives of Regulatory Mechanisms are: (1) to identify mechanisms by which gravity affects cells and organisms emphasizing neural, endocrine, metabolic adaptation, and systemic response mechanisms; (2) to determine ionic mediators of gravity effects on regulatory mechanisms; (3) to determine the importance of interaction of environmental factors (e.g., temperature and light) with gravity in altering regulatory mechanisms; and (4) to use microgravity as a tool to understand if gravity directed evolution of regulatory mechanisms. Ground-based and spaceflight experiments are both required.

W88-70342 **199-52-12**
Ames Research Center, Moffett Field, Calif.
COSMIC EVOLUTION OF BIOGENIC COMPOUNDS
T. Bunch 415-694-5909
(199-52-22; 199-52-32; 199-52-42)

The overall concept of the program is to understand the history of biogenic elements (C, H, N, O, P, S) and their compounds in the galaxy and the early solar system. The program has three basic goals: (1) trace the physical and chemical pathways taken by the biogenic elements and their compounds from their origins in stars to their incorporation in the pre-planetary bodies; (2) determine the kinds of measurements that can be made on the biogenic elements and compounds in the galaxy and solar system and the prebiotic evolution and origin of life; and (3) determine the ways in which the physical and chemical properties of the biogenic elements and compounds may have influenced the course of events during the formation of the solar system and the component bodies. A series of workshops has explored major scientific questions, to determine which are amenable to theoretical, experimental, observational or analytical approaches and to recommend the major research areas of the program that are necessary to pursue defined goals and objectives. These recommended research thrusts are nucleosynthesis of biogenic elements with ejection into the interstellar medium, chemical evolution in the interstellar medium, protostellar collapse, chemical evolution in the solar system, growth of planetesimals from dust, and accumulation and thermal processing of planetoids.

W88-70343 **199-52-14**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ORGANIC CHEMISTRY OF COMETS
M. S. Hanner 818-354-4100

The spectrum of Halley had an emission feature at 3.36 micrometers and the grain composition was high in H, C, N, and

O. Grains were the likely source of excess CO, C(+) and CN detected in the coma. We plan to undertake a systematic study of gas-grain chemical interactions using the Jet Propulsion Laboratory's (JPL) Planetary Surface Facility. Infrared reflectance and transmittance spectra of the solid phase reaction products will be obtained for comparison with the comet spectrum. Our goal is to understand the carbon budget of the comet and the chemical evolution of the organic components in grains. We will carry out systematic studies of: (1) the kinetics of binary ices under ultraviolet (UV) irradiation at T greater than 20K; (2) adsorption of gas molecules and radicals on solid surfaces, such as amorphous carbon, formation of new species on the surface during irradiation, and the gaseous emission products when the sample is subsequently heated or irradiated; and (3) reflectance and transmittance spectra of the products formed in (1) and (2); it is well-known that the fundamental molecular vibration frequencies are altered by coupling with the solid-state lattice.

W88-70344 **199-52-22**
Ames Research Center, Moffett Field, Calif.
PREBIOTIC EVOLUTION
S. Chang 415-694-5733
(199-52-12; 199-52-32; 199-52-42)

The objective of research in prebiotic evolution is to understand the impact of the development of Earth and other planets on the evolutionary sequence leading from simple chemicals to living systems. The approaches taken to meet the objective fall into two major study areas, each of which involves the use of both laboratory experiments and computer simulations: (1) the consequences of planetary evolution on the physical environments of the Earth and planets; and (2) the evolution of molecules and molecular systems under the constraints imposed by the physical environment, and by the appearance, a posteriori, of living systems on Earth. Studies of planetary evolution assess the importance of the physical-chemical processes associated with the dynamic development of planetary surfaces, on both global and microenvironmental scales, which could have been involved in, or provided constraints on the development of living systems for Earth and other planets. Studies of molecular evolution focus on the energetics, dynamics and synthesis of chemicals and chemical systems in order to elucidate feasible mechanisms by which these systems acquired biological attributes within the constraints of the environment.

W88-70345 **199-52-26**
Langley Research Center, Hampton, Va.
EARLY ATMOSPHERE: GEOCHEMISTRY AND PHOTOCHEMISTRY
Joel S. Levine 804-865-2187

Objectives are to develop a better understanding of the geochemical and photochemical processes that controlled the composition of the atmosphere over geological time. The approach consists of: (1) the development and application of a geochemical flux model to investigate the transfer of carbon, nitrogen, oxygen, hydrogen, sulfur, and chlorine species between the atmosphere, oceans, solid earth, and biosphere over geological time; (2) photochemical calculations of the composition of the early atmosphere and its evolution over geological time; (3) laboratory lightning experiments in various paleoatmospheric gas mixtures in the Langley Lightning Facility; and (4) studies of the geochemistry, geology, and atmospheric chemistry of early Mars to better understand the early Earth and to assess the possibility of life on Mars.

W88-70346 **199-52-32**
Ames Research Center, Moffett Field, Calif.
THE EARLY EVOLUTION OF LIFE
L. I. Hochstein 415-694-5938
(199-52-22; 199-52-42)

This research explores the mechanisms, processes and environments associated with the early evolution of life on Earth as an approach for understanding life elsewhere in the universe. Two repositories of evolutionary information are examined, namely, the molecular record in living microorganisms and the geologic record in rocks. Biological studies address the early evolution of the complex systems that constitute the essential attributes of life. Energy transduction is being studied by examining archaebacteria (e.g., extreme halophiles, thermophilic acidophiles) and comparing their properties with those of eubacteria. The development of oxygen-requiring pathways in lipid synthesis is investigated both in eubacteria and in eukaryotes. Geologic studies seek to elucidate earlier biochemistries through analyses of ancient biological material preserved in stromatolitic rocks. The paleoenvironment (e.g., its structural setting and the chemical composition of its ocean and atmosphere) is also being described. The goal is to understand the nature and evolution of primitive microorganisms, especially in the context of those forces which guided the evolution of the planet itself.

W88-70347 **199-52-42**
Ames Research Center, Moffett Field, Calif.
EVOLUTION OF ADVANCED LIFE
D. Des Marais 415-694-6110
(199-52-22; 199-52-32; 199-52-62)

The goals of this research are to understand possible evolutionary pathways for advanced life, to examine the influence of astrophysical stellar and solar system events on the evolution of advanced life on Earth, to investigate ancient atmospheres, and to develop a program plan for a paleontological data base. Specific correlations will be sought between extraterrestrial interventions and major events in biological evolution. The geologic record is to be examined for geochemical indicators of meteoritic and cometary impacts. Features of the record such as periodicities, selectivity of biological extinctions, and the biological consequences of other natural planetary phenomena (e.g., volcanic, oceanic, and atmospheric effects) will be explored.

W88-70348 **199-52-52**
Ames Research Center, Moffett Field, Calif.
SOLAR SYSTEM EXPLORATION
G. C. Carle 415-694-5765
(199-52-12; 199-52-22)

The objective of this research is to provide specific information on the elemental and chemical composition, mainly in respect to gases and volatiles, of the atmospheres and surfaces of solar system bodies including planets and their satellites, comets, asteroids, meteorites, and dust in space. This information is essential for selecting or devising the most appropriate model for the evolution of the solar system and for each of the investigated bodies. Further, it will provide a basis for understanding the conditions necessary for the origin of life by comparisons of the evolutions and chemistries of these bodies. Improved methods, instrumentation, and experiments will be defined and developed for in situ chemical analyses of the volatile species associated with the bodies to be investigated. Special emphasis is directed to development of the gas chromatographic approach since it is now proven to be among the most effective means for measuring complex gaseous mixtures. Improvements in gas chromatographic techniques, e.g., multiplex chromatography, and components, e.g., detectors and columns, will be rigorously explored. Other techniques will be investigated and developed as appropriate.

W88-70349 **199-52-62**
Ames Research Center, Moffett Field, Calif.
THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (SETI)
B. M. Oliver 415-694-5166

The Search for Extraterrestrial Intelligence (SETI) program is an R and D effort which has the following five objectives: (1) to conduct an extensive R and D effort to determine the most cost effective way to do SETI and to carry out limited but significant SETI observations; (2) to design, build, and test a SETI prototype system; (3) to field test the prototype at Goldstone and Arecibo for initial SETI observations; (4) to evaluate the SETI system for its value for radio astronomy; and (5) to explore new technologies for SETI. In accomplishing these objectives, telescope to SETI

hardware interfaces will be determined, data acquisition software developed, and various signal processing and identification methods examined in software and optimized for implementation in hardware. The signal processing system will permit a search for signals of natural and artificial origin over the entire sky between 1 and 10 GHz up to a maximum sensitivity of 10 to the -23rd watts per square meter, and a search for selected solar-type stars in the 1 to 3 GHz range up to a maximum sensitivity of 10 to the -27th watts per square meter. The hardware development proceeds in stages from proof-of-concept (POC) prototype to an Initial Operation Configuration (IOC) for a Targeted Search system and an Engineering Design Model (EDM) for the Sky Survey system (both capable of real time field operation), through the final Extended Operating Configuration (EOC) for production and deployment in the Microwave Observing Project.

W88-70350 **199-61-12**
Ames Research Center, Moffett Field, Calif.
BIOREGENERATIVE LIFE SUPPORT RESEARCH (CELSS)
R. D. MacElroy 415-694-5573
(199-61-23; 199-61-32)

This RTOP supports the scientific experiments and technological investigations and potential flight experiments necessary for the development of bioregenerative life support systems. Investigations are directed toward the practical use of higher plants, algae, microorganisms and physical-chemical devices for the production of water, food and oxygen, and absorption of carbon dioxide and waste materials in orbit or on planetary surfaces. The goal is to insure recycling and regeneration of materials needed for crew support. Included also are studies of the control and the efficiency of such bioregenerative systems. These investigations are concerned with the rates at which organisms or physical-chemical devices produce or consume biomass, food, oxygen, carbon dioxide, potable water, and fixed nitrogen in response to changes in environmental variables such as temperature, atmospheric gas composition, light intensity, duration and quality, humidity, wind speed, and the composition of nutrient medium. These investigations are also conducted to improve the methods available for increasing system efficiency, stability and control through automated sensing, data collection, and data interpretation. Data collected forms a science-requirements base for the design and operation of the Controlled Ecology Life Support System (CELSS) Breadboard Project.

W88-70351 **199-61-32**
Ames Research Center, Moffett Field, Calif.
BIOREGENERATIVE LIFE SUPPORT FLIGHT EXPERIMENTS AND TESTS
R. D. MacElroy 415-694-5573
(199-61-12; 199-61-23)

This RTOP supports the scientific and technological work required for the development of the requirements, concepts and initial designs for the tests, experiments and hardware devices that will be used for Controlled Ecology Life Support System (CELSS) space flight experiments. The flight experiments envisioned will involve investigations of the effects of the space environment (micro-gravity and higher radiation fluxes) on the productivity of potential food materials by higher plants and algae. The tests required will primarily concern evaluation of devices capable of directing and controlling the flow of liquids, and the separation of liquids and phases. Both of these techniques are essential for the development of non-stressful growth environments for higher plants and for the growth and harvesting of single-celled organisms. Scientific and technological requirements will be developed through the convening of workshops and other advisory panels which will bring together scientific and engineering experts to consider, discuss, evaluate and prioritize basic concepts for flight experiments and tests. Requirements of specific experiments and tests, for example, for physical size and power demands, will be estimated and compared to capabiiities available on potential, proposed or planned space missions. The flight mission capabilities to carry and conduct the various experiments will be determined, and preliminary designs for hardware will be produced. Mock-ups of the hardware will be developed for the purposes of evaluating the experiment fit to the mission and the characteristics of the operating experiment. This work will be done with the direct involvement of panels of experts in science and engineering.

W88-70352 **199-70-12**
Ames Research Center, Moffett Field, Calif.
EXTENDED DATA BASE ANALYSIS
Rodney W. Ballard 415-694-6748

The objective of this effort is to expand the use of computer assisted analysis of data from spaceflight experiments. This also includes the development of techniques to relate spaceflight and ground collected experiment data. The work involved in this RTOP includes extending the opportunity for science investigators to extend and enhance the analysis of data that has been previously collected in spaceflight experiments, and the development of new approaches to increase the scientific yield of flight data. This RTOP will also support the publication and presentation of significant results.

W88-70353 **199-70-22**
Ames Research Center, Moffett Field, Calif.
DATA ANALYSIS: EXOBIOLOGY PLANETARY DATA STUDIES AND LIFE SCIENCE DATA SYSTEM DEVELOPMENT
G. C. Carle 415-694-5765
(199-52-52)

The objective of this RTOP is to provide new data bases and conduct studies of existing data bases which are supportive of Life Sciences science goals in previous and future flight experiments. During previous planetary missions, particularly from the Mariner and Viking missions to Mars, data bases were accumulated which contain information that can be used in the study of the appearance of life in the solar system. Detailed studies of these data bases will produce new insight into possible early evolution of life on Mars as well as aid in the selection of landing sites for future Mars missions where exobiology science goals can be addressed. In future Earth orbit missions, various Life Sciences flight experiments will be flown which will generate new data bases containing information from the specific parameters being monitored. To enhance capability for real-time acquisition and the ultimate production of fully accessible archival data, advanced ground-based data systems will be developed which have high portability and are easily accessed through high level languages.

W88-70354 **199-70-32**
Ames Research Center, Moffett Field, Calif.
DATA ANALYSIS TECHNIQUES: ADVANCED DATA HANDLING STUDIES FOR LIFE SCIENCES FLIGHT EXPERIMENTS
G. C. Carle 415-694-5765
(199-52-52; 199-52-12; 199-52-22)

The objective of this RTOP is to provide advanced data analysis techniques for future Life Sciences flight experiments in Earth orbit and in solar system exploration. While Life Sciences encompasses many diverse science disciplines ranging from exobiology to biomedicine, there is a universal need among these disciplines to conduct flight experiments to meet the goals of each particular program. By developing new and more efficient analytical approaches based on advanced computational techniques for these missions, flight experiments which focus on each program's interests can be more effective in competing for the limited space on available missions as well as make better use of the collected flight data. In the area of exobiological solar system exploration experiments, these limitations are particularly severe. Therefore, new analytical approaches based on advanced computational techniques will be developed which will significantly increase the data returned from a flight experiment without increasing the requirements for spacecraft resources. In the area of Earth orbit flight animal and biomedical experiments, there are a number of requirements for monitoring a wide variety of physiological parameters during missions. To meet these requirements, an agency-wide flight data handling and analysis system for future Spacelab Life Sciences experiments will be

developed. This system will allow for real-time data analysis and experimenter/experiment interaction in future missions. Additionally, to aid in flight physiological studies, accurate mathematical models of physiological effects of microgravity will be developed.

W88-70355 **199-80-00**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF REMOTE SENSING INSTRUMENTS
James G. Lawless 415-694-5900
(199-30-32; 199-30-62; 199-30-72)

Instruments for supporting biospherics research in two areas, ground and aircraft, will be developed. The aircraft related instruments include a calibrated, multispectral thermal scanner, upgrades to available scanners, and a high spectral resolution imaging scanner for biological remote sensing. Development of the two new scanners will begin, following a workshop to establish and develop specifications. The ground related instruments include a quick remote sensing data reception system, a field foliage fluorescence probe, and a plant canopy geometry probe. Development of the last two will involve development of specifications and identification of vendors, and final award of contracts for prototype instruments.

W88-70356 **199-80-34**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ULTRASOUND IMAGE ENHANCEMENT
R. H. Selzer 818-354-5754
(199-10-24)

The basic objective of this research is to apply digital image processing techniques to ultrasound images obtained in collaboration with the French. Use of image processing techniques developed at the Jet Propulsion Laboratory (JPL) may permit quantification and improved display of these medical ultrasound data. Such improvements will lead to the extraction of additional data of clinical interest from the videotapes. Studies have been underway to develop image enhancement and scene analysis techniques that could be applied to ultrasound images from the Centre Nationale d'Etudes Spatiales (CNES) second generation ultrasound imaging system. The original intent was first to develop and test two-dimensional processing algorithms and then to extend the technique to the three-dimensional case. A system for processing of flight data, either on-board or with a ground-based system, was to be specified. Implementation responsibility was not yet defined. Because of the decision to phase out this activity, the effort in FY88 will provide documentation and other technology transfer support for the 2D methods developed to date. In addition, an evaluation of a potential 3D imaging technique will be made.

W88-70357 **199-80-82**
Ames Research Center, Moffett Field, Calif.
ADVANCED TECHNOLOGY DEVELOPMENT: FUTURE LIFE SCIENCES FLIGHT EXPERIMENTS
G. C. Carle 415-694-5765
(199-52-52)

Studies will be conducted to provide fully developed advanced flight instrumentation concepts and laboratory breadboards for future Life Sciences flight experiments where accurate, comprehensive, and sensitive instruments and highly specialized devices will be required. These instruments, experiment concepts, and devices are critical to the science needs of the Life Sciences community to gain specific data only obtainable from space flight and unaddressed elsewhere, e.g., Exobiology for measurements of the biogenic elements and their compounds in solar system exploration and Life Support for monitoring of the cabin environments of Space Station. Instrument and experiment development based on advanced analytical concepts and engineering technology will be conducted. Feasibility studies will be performed and based on validated concepts. Prototypes will be constructed and tested. Experiments and instruments based on these development efforts will be proposed for flight.

W88-70358 **199-80-92**
Ames Research Center, Moffett Field, Calif.
ATD NEAR TERM FLIGHT HARDWARE DEFINITION
G. H. Bowman 415-694-6273

The objective of this RTOP is to support the preliminary design, early development and testing of hardware required for projected flight experiments. New hardware will be identified through the analysis of scientific objectives and requirements described in the responses to the Announcement of Opportunity (AO), and through previous flight experiences. The newly identified hardware will undergo further detailed requirements definition, an assessment of available state-of-the-art components, a conceptual design, and finally, breadboarding and testing. After the prototype has been developed the Life Sciences Flight Experiments Program will assume the responsibility for developing the flight hardware.

W88-70359 **199-90-67**
Ames Research Center, Moffett Field, Calif.
TETHERED ARTIFICIAL GRAVITY RESEARCH FACILITY STUDY
L. G. Lemke 415-694-6531
(450-16-12)

The objective of this RTOP is a preliminary mission and system definition for a space-based human-rated centrifuge to function as an Artificial Gravity Research Facility (AGRF) and identification of precursor technology development activities, including both ground- and space-based experiments. The AGRF will become operational during the post-Permanent Manned Configuration (PMC) phase of the Space Station and may be enabled or significantly enhanced by operating attached or in close proximity to the Station. The primary mission of the AGRF will be for the conduct of basic and applied life-sciences research with particular emphasis on the effects of variable gravity, partial gravity, and rotating reference frames on human subjects. The approach for this RTOP is to: (1) define the technical and programmatic requirements for an AGRF by interaction with the life-sciences research community and the NASA long-duration manned-mission planning teams; (2) identify and define major technical system options and trade-offs by performing definition studies, and (3) identify significant technology developments required and propose experiments to achieve them.

W88-70360 **199-90-72**
Ames Research Center, Moffett Field, Calif.
AMES RESEARCH CENTER INITIATIVES: LIFE SCIENCE OVERGUIDELINE
Alan B. Chambers 415-694-5094

The mission of the Space Research Directorate at Ames Research Center is to contribute materially to the knowledge of phenomena in the atmosphere and space by conducting studies and experiments that expand our understanding of the earth, solar system, and the universe; the origin, evolution, and distribution of life, and the effect of space flight on man and other organisms. Expressed in one mission statement, or represented by numerous goals, the fundamental purpose of the Space Research Directorate is to apply an intense interdisciplinary approach to the study of life, earth, and space, and develop an understanding of the relationships between these intersecting facets of the same cosmic gem. The Center Initiatives RTOP provides the appropriate flexibility in the accomplishment of our mission by supporting preliminary, innovative research pursuits in space research.

Solar Terrestrial Theory Program

W88-70361 **441-03-02**
Goddard Space Flight Center, Greenbelt, Md.
MHD TURBULENCE, RADIATION PROCESSES AND ACCELERATION MECHANISMS IN SOLAR AND MAGNETOSPHERIC PLASMAS
M. L. Goldstein 301-286-7828

The objectives of this RTOP are: (1) to study

magnetohydrodynamic (MHD) turbulence, radiation processes, and particle acceleration mechanisms in solar and magnetospheric plasmas; (2) to publish in the scientific literature and to present at professional meetings the significant results of such research; and (3) to collaborate with and support theoretical research of graduate students, research associates, and coinvestigators from other academic institutions who work on the subject matter of this RTOP. Research on MHD turbulence will be carried out by M. L. Goldstein and A. Vinas of the Laboratory for Extraterrestrial Physics in collaboration with W. H. Matthaeus of the Bartol Research Institute and J. J. Ambrosiano of Berkeley Research Associates. Particle acceleration in solar flares will be studied by R. Ramaty of the Laboratory for High Energy Astrophysics and C. J. Crannell and D. S. Spicer of the Laboratory for Astronomy and Solar Physics. Shock acceleration research will be carried out by F. C. Jones of the Laboratory for High Energy Astrophysics, D. Eichler and D. C. Ellison of the University of Maryland, and M. A. Forman of the State University of New York.

Solar Terrestrial SR&T

W88-70362 **442-00-00**
Marshall Space Flight Center, Huntsville, Ala.
TRACE CONSTITUENTS IN THE STRATOSPHERE
M. R. Torr 205-544-7676

The primary objective of this RTOP is to support and participate in balloon flights of a high resolution ultraviolet spectrograph designed to measure OH and other key trace constituents in the stratosphere. The investigation represents a capability to obtain limb scans (from which height profiles can be inverted) of OH ultraviolet (UV) emissions for the duration of the time that the balloon remains at float altitude (several hours). The instrument has been developed and successfully tested on balloon flights. This activity is for a three-year operational program with the aim of obtaining a database on OH height and time variations spanning various seasons and conditions. The activity is a joint program with The University of Alabama in Huntsville (UAH). The costs for the UAH participation are not included in this RTOP but in a separate proposal.

W88-70363 **442-20-01**
Marshall Space Flight Center, Huntsville, Ala.
SPACE PLASMA DATA ANALYSIS
C. R. Chappell 205-544-7591
(442-36-55)

The objective of this RTOP is an adequate understanding of the dynamics of low-energy plasma in the earth's magnetosphere. This research involves the analysis of data from spacecraft and ground-based laboratory investigations. This individual RTOP consists of a coordinated set of tasks which includes: (1) analysis of the Light Ion Mass Spectrometer (LIMS) data from the NASA/DOD Spacecraft Charging at High Altitude (SCATHA) satellite; (2) laboratory simulation of plasma flow around different objects; (3) modeling of thermal plasma processes; (4) analysis of data and development of models relating to the effects of spacecraft plasma sheaths upon low-energy charged particle data; and (5) analysis and development of models relating to plasma wave processes in multispecies plasmas.

W88-70364 **442-20-01**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE PLASMA LABORATORY RESEARCH
Andrei Konradi 713-483-5059

A significant program in space plasma physics has been in existence at the Johnson Space Center for over a decade. This encompasses both plasma and ionizing radiation data from various spacecraft and laboratory research carried out in JSC's Chamber A and a laboratory size plasma facility. The objectives of the program are: (1) to continue studies of the natural space environment utilizing rocket, ground based, and space flight data; (2) to continue laboratory research into the properties of space plasma and of its interaction with spacecraft bodies; and (3) to provide support to outside scientists in need of a laboratory facility capable of generating an ionosphere-like plasma environment. We intend to pursue both analytic studies and experimental investigations by means of particle detectors flown on spacecraft that lead to an improvement of our current models of the magnetospheric, galactic, and solar ionizing radiation and our ability to predict transient particle events. We will continue our studies of the interactions of the ionospheric plasma with spacecraft and the effects of man-made perturbations, and will maintain, augment and in general make our plasma chamber available to outside experimenters.

W88-70365 **442-20-01**
Goddard Space Flight Center, Greenbelt, Md.
ATMOSPHERE IONOSPHERE MAGNETOSPHERE INTERACTIONS
R. E. Hartle 301-286-8234

The basic objective is to study the observed properties of the ionosphere, mesosphere, thermosphere, exosphere and inner magnetosphere, and to identify and understand the physical and chemical processes operating in these regimes, emphasizing how they interact. This is achieved by processing, analyzing and interpreting experimental data derived largely from flight programs after funding from project offices has terminated, permitting the study of long-term phenomena, comparison of data with new theories and models, correlative studies of data obtained from various satellites and ground based observatories, and the deposition of additional data in the National Space Science Data Center. The essential data to be used in this investigation include electron densities and temperatures, ion and neutral composition, neutral winds, ion temperatures and drifts, electric fields, magnetic fields, electromagnetic radiation and energetic particles of magnetospheric and ionospheric origin. These data are used to determine the various interrelated chemical, compositional, dynamical and energetic states of the ionosphere, exosphere, thermosphere and mesosphere and the transport and deposition of mass, momentum and energy in and between these physical regions. These basic properties and processes are then used to analyze specific geophysical phenomena such as: atmospheric escape, electric field induced ion drifts in the ionosphere, chemistry and dynamics of mid and high latitude troughs, auroral substorms, ionospheric storms, Joule heating, polar cap absorption (PCA) events, tidal and gravity waves, depletion and filling of plasmasphere, ionospheric electrodynamic processes, equatorial bubble formation, stable auroral red (SAR) Arcs, etc.

W88-70366 **442-20-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTERPLANETARY SPACE AND PLASMA PHYSICS: MAGNETOSPHERIC AND INTERPLANETARY PHYSICS, INTERPLANETARY CAUSES OF GEOMAGNETIC ACTIVITY, INTERPLANETARY SCINTILLATIONS
E. J. Smith 818-354-4110

This RTOP encompasses three continuing subtasks involving the analysis of: (1) magnetospheric and interplanetary data obtained by magnetometers and plasma wave instruments (E. J. Smith); (2) solar - interplanetary - magnetospheric coupling processes and wave-particle instabilities in magnetospheres and interplanetary space (B. T. Tsurutani), and (3) interplanetary scintillations using spacecraft radio signals (R. Woo). The objective of the first subtask is the analysis and interpretation of scientific data from the Pioneer Vector Helium Magnetometers and from the International Sun-Earth Explorer (ISEE) plasma wave instruments. Research topics involving the ISEE-3 magnetometer not supported by the project are also included. The data have previously been reduced using project funds and are available for intensive analysis in studying problems of current scientific interest. The objective of the second subtask is analysis of ISEE-1, -2, -3 magnetic field, plasma and plasma wave data, IMP-8 (Explorer) field and plasma data and Caltech Solar H(alpha) filtergrams and magnetograms. The objective of the third subtask is the use of radio signals received from deep space missions (Pioneer, Helios, Voyager, etc.) to probe

regions of the solar wind that are inaccessible to direct measurement.

W88-70367 **442-20-02**
Goddard Space Flight Center, Greenbelt, Md.
DATA ANALYSIS: SPACE PLASMA PHYSICS
L. F. Burlaga 301-286-5956

The basic objective is to study the observed properties of the interplanetary medium and the magnetospheres of the earth and other planets and to identify and understand the physical processes operating within and between these regimes. This is achieved by processing, analyzing and interpreting experimental data derived largely from flight programs after funding from project offices has terminated, permitting the long-term phenomenological studies, comparisons of data with new theories and models, correlative studies of data obtained from various satellites and ground-based observatories, and the deposition of additional data in the National Space Sciences Data Center (NSSDC). The essential data to be used in this investigation include measurements of magnetic fields, plasmas, energetic particles, plasma waves and radio radiation. These data are used to determine the various dynamical and energetic states of the interplanetary medium and the magnetosphere and to assess the transport and deposition of matter and energy within and between these physical regions. These basic properties and processes are then used in the study of specific geophysical phenomena such as interplanetary sectors and flows, energetic particle acceleration, auroral current systems, and magnetic fields and plasma in the plasma sheet and the magnetotail. Basic theory complementary to the data analysis effort is carried out in the areas of kinetic plasma physics and the motion of charged particles in the electric and magnetic fields.

W88-70368 **442-20-03**
Goddard Space Flight Center, Greenbelt, Md.
NSESCC FACILITY
Melvyn L. Goldstein 301-286-7828

The objective of this RTOP is to support the operating budget of the NASA Space and Earth Sciences Computing Center (NSESCC) associated with very large-scale computational support of RTOP related research within the Space Plasma Physics program. The funding support of $150,000 will provide a total allocation of 1200 to 1500 Computing Units (CUs). The total allocation will be distributed to individual researchers both at Goddard and external universities, in accordance with the computational needs of the space plasma physics community.

W88-70369 **442-20-04**
Goddard Space Flight Center, Greenbelt, Md.
ENERGETIC PARTICLES AND PLASMAS IN THE MAGNETOSPHERES OF JUPITER AND SATURN
T. G. Northrop 301-286-7516

The overall objective of this study is to gain an understanding of the sources, sinks and dynamics of charged particles (electrons, ions, and charged dust grains) in the magnetospheres of Jupiter, Saturn, Earth, Uranus and pulsars. This work will apply plasma theory and the theory of charged particle motion to data taken by Pioneers 10 and 11, and by Voyagers 1 and 2. Included is a study of the effect of particle stability on the gross structures in Saturn's rings, structures which have not been explained by purely gravitational forces on the ring material by Saturn and its moons. We have prior to now been successful in pointing out the possible role of electromagnetic forces combined with gravitational forces in producing some major changes in optical depth with radius observed by the Voyagers. We have started an extension of this work to derive a model for the equilibrium of charged dust grains in a ring system. Such a model is needed to complete the identification of the inner edge of Saturn's B ring with the inward stability limit of such grains in the ring plane. The stability calculation, being linear, is much simpler than the equilibrium, which is non-linear and probably involves solution of the Poisson equation in the presence of field-aligned currents through Saturn's ionosphere. An explanation of how an equilibrium (stable or unstable) might occur would make the identification much more convincing.

W88-70370 **442-20-05**
Goddard Space Flight Center, Greenbelt, Md.
MAGNETOHYDRODYNAMIC CELLULAR AUTOMATION STUDIES
Melvyn L. Goldstein 301-286-7828

The objectives of this RTOP are: (1) to study magnetohydrodynamic (MHD) turbulence using the techniques of cellular automata as a means of solving the partial differential equations which describe magnetohydrodynamics; (2) to publish in the scientific literature and to present at professional meetings the significant results of such research; and (3) to collaborate with and support theoretical research of graduate students, postdoctoral associates, and coinvestigators from other academic institutions who work on the subject matter of this RTOP. Research on the use of cellular automata in the study of MHD turbulence will be carried out by M. L. Goldstein of the Laboratory for Extraterrestrial Physics in collaboration with W. H. Matthaeus and Hudong Chen of the Bartol Research Institute and L. W. Klein of Applied Research Corporation. Progress in this area also requires support in utilizing and programming Goddard's Massively Parallel Processor. This support will be provided under an RTOP being submitted by J. Dorband of the Image Analysis Facility (Code 635) to Code R. The research proposed here is a continuation and expansion of research begun under the auspices of a grant from the Director's Discretionary Fund during this past year.

W88-70371 **442-20-11**
Goddard Space Flight Center, Greenbelt, Md.
PRESERVATION AND ARCHIVING OF EXPLORER SATELLITE DATA
R. A. Hoffman 301-286-7386

The NASA Explorer Project Scientists for Explorers (IMP), Dynamics Explorers (DE) and International Sun-Earth Explorers (ISEE) have proposed a set of projects whose general objective is to establish archives of spacecraft data for long-term access in a convenient form. The specific objectives include: (1) development of techniques and realistic cost estimates to recover data from old and possibly deteriorated magnetic tapes for subsequent transfer for archival purposes to optical disks; (2) development of methods to transfer data from magnetic tapes to optical disks and to use the optical disks in an operational environment; (3) development of procedures and techniques for the National Space Sciences Data Center (NSSDC) to acquire data processed at experimenters' facilities and utilized for analyses, and to transfer these diverse data sets to a common format on optical disks; and (4) production of the data sets which have been identified, and their dissemination to users. For objectives (1) and (3), candidate data sets from IMP and ISEE would first be identified, upon which detailed approaches would be developed for the subsequent work. With the diverse formats and time resolutions available, the feasibility of converting the data to a common format and consistent time resolution will be investigated. For objective (2), software will be developed to convert the DE tape telemetry data base from Sigma-9 format to optical disks running on DEC VAX computers.

W88-70372 **442-36-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SOLAR WIND STUDIES AND MAGNETOSPHERE/IONOSPHERE INTERACTIONS
M. Neugebauer 818-354-2005
(188-38-01)

Solar-wind data obtained by past space missions are used to address important questions in solar and heliospheric physics, including: How does the frequency of occurrence of rotational discontinuities (RDs) and tangential discontinuities (TDs) in the solar wind depend on the type of flow (the three types considered are flow from coronal holes, coronal mass ejections, and flow associated with coronal streamers)? What can discontinuities tell us about acceleration of the solar wind by waves or about the discreteness of individual plasma parcels in the corona? An

additional task is the preparation of a review paper on the topic of The Problem of Associating Solar and Interplanetary Events. A theoretical investigation of ionosphere-magnetosphere coupling is conducted to evaluate the effect of neutral ionospheric winds on plasma convection in the magnetosphere, and the driving of these neutral winds by magnetospheric plasmas during substorms.

W88-70373 **442-36-20**
Marshall Space Flight Center, Huntsville, Ala.
EXPERIMENTAL AND THEORETICAL STUDIES OF NATURAL AND INDUCED AURORAS
M. R. Torr 205-544-7676

A primary objective of this RTOP is to develop a prototype compact vacuum ultraviolet (VUV) imager for ultimate use on a sounding rocket or on the Remote Manipulator System (RMS) of the space shuttle to study induced auroras under sunlit conditions, natural auroras, chemical releases, and upper atmospheric composition and kinetics via limb imaging. A correlated experiment with this instrument and the Space Experiment with Particle Accelerators (SEPAC) electron accelerator provides a means to calibrate the theoretical models needed for interpreting the International Solar Terrestrial Physics (ISTP) imaging data. The instrument to be developed uses an intensified two-dimensional charge coupled device (CCD) as the focal plane detector. A second primary objective is the modeling of emissions in this spectral range, which are induced by both natural and artificial means, to characterize the impact energy of the particles. Without the modeling task, the value of the measurements cannot be realized.

W88-70374 **442-36-55**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STARPROBE TECHNOLOGY AND MISSION PLANNING
James E. Randolph 818-354-2732

This RTOP will support Starprobe advanced technical development studies leading to a viable program plan to implement the mission. Specific objectives include: completion of the data analysis and reporting the results of the thermal shield testing program in conjunction with the French agencies Centre National d'Etudes Spatiales (CNES) and Centre National de la Recherche Scientifique (CNRS); (2) analysis of the interplanetary trajectory options in light of new trajectory concepts including multiple planetary gravity and Venus (or earth) aero-gravity assist concepts; (3) modifications to existing spacecraft designs Mariner Mark 2 (or Mars Observer) to allow their utilization for Starprobe; (4) development of a plan for a renewed program with a possible Phase A in FY89 and FY90; and (5) maintaining liaison with the ESA Solar Probe study. A study team will continue to function that will have tasks including the final analysis and publication of the thermal test program results in conjunction with the French agencies CNES and CNRS. The new interplanetary trajectory types (e.g., broken plane trajectories to Jupiter) by the Galileo and Ulysses projects have not been studied for the Starprobe mission and may yield performance advantages that should be investigated by the team. It has been many years since the spacecraft design options have been studied by the team in the context of on-going inheritable hardware designs. We will consider the Mariner Mark 2 and Mars Observer as candidates for the Starprobe spacecraft. Finally, the program will develop new credibility when the thermal shield test results are completed and a new program plan can be developed during FY88. This plan will incorporate the results of previous studies with the possibility of collaborative options with the European Space Agency.

W88-70375 **442-36-55**
Ames Research Center, Moffett Field, Calif.
MAGNETOSPHERIC PHYSICS: PARTICLES AND PARTICLE/FIELD INTERACTION
A. Barnes 415-694-5506

The overall objective of this research is to investigate the solar wind, its origin, termination, dynamics and turbulence, as well as its interaction with planetary obstacles. Theoretical studies will be conducted, aimed at understanding the large-scale dynamics of the solar wind, its acceleration and heating mechanisms, and waves and turbulence in the solar wind. These studies employ known theoretical techniques of plasma physics and magnetohydrodynamics, and also often require extensions of basic theoretical plasma physics. Theoretical developments will be related to spacecraft plasma and magnetic data, as well as to indirect observations of the solar wind. Theoretical studies of the solar wind Venus interaction will be conducted.

W88-70376 **442-36-55**
Goddard Space Flight Center, Greenbelt, Md.
PARTICLES AND PARTICLE/FIELD INTERACTIONS
Keith W. Ogilvie 301-286-5904

The object of this research is to increase the knowledge and understanding of non-thermal plasmas occurring in the interplanetary medium and magnetospheres of earth and other planets. This requires continuous improvement of measurement techniques, concentrating on advanced concepts of plasma detectors, ion mass discrimination at high energies, magnetometers and radio and plasma wave analyzers. Work is also underway to improve the theoretical description of plasma properties and to improve techniques for the interpretation of the results of space plasma experiments, requiring corresponding improvements in numerical techniques and in methods of data display.

W88-70377 **442-36-55**
Marshall Space Flight Center, Huntsville, Ala.
SPACE PLASMA SRT
T. E. Moore 205-544-7633
(442-20-01)

The objectives of this and another closely related RTOP are to develop space plasma instrumentation for automated spacecraft, sounding rocket, and shuttle payloads. To accomplish these objectives, the following tasks will be performed. First, an advanced low-energy ion mass spectrometer will be designed and developed for the measurement of low-energy plasma distributions in the ionosphere and magnetosphere. Instruments have been flown on several sounding rockets. An angle scanning, differential energy analyzer with excellent mass resolution will be developed for future applications. Second, development will continue on a low-energy electron analyzer tailored to measurement of positive spacecraft floating potential. This concept has been successfully demonstrated in the laboratory and will be upgraded to flight-quality hardware. Development of an improved electron beam and solar ultraviolet (UV) facility is planned.

W88-70378 **442-36-56**
Goddard Space Flight Center, Greenbelt, Md.
PARTICLE AND PARTICLE/PHOTON INTERACTIONS (ATMOSPHERIC MAGNETOSPHERIC COUPLING)
James P. Heppner 301-286-8797

The objective is to develop experimental and theoretical approaches for investigating the processes which provide strong coupling between the neutral atmosphere, the collision dominated ionospheric plasma, and the collisionless magnetospheric plasma. Within the framework of this overall objective, specific sub-objectives are identified in terms of having key significance, goals which are attainable with limited resources, and close ties to future projects and programs. Emphasis is placed on electric fields and the associated transport and energization of particles that occur within the earth's magnetic and gravitational fields. Related topics include electric fields in the earth-ionosphere cavity, the transformation of atmospheric ions to trapped radiation, auroral particle acceleration mechanisms, and plasma instabilities producing ionospheric irregularities. Improved instrumentation is being developed for low light level observations of tracer chemicals, measurements of low energy particles and electron temperature and density measurements. Properties of double probes in low plasmas are being studied. Models for the injection, diffusion, and transport of tracer particles are being developed for planning and interpreting future chemical release experiments.

W88-70379 **442-36-57**
Goddard Space Flight Center, Greenbelt, Md.
PARTICLE ACCELERATOR FACILITY: MAINTENANCE AND OPERATION OF A CALIBRATION FACILITY FOR MAGNETOSPHERIC AND SOLAR-TERRESTRIAL EXPERIMENTS
S. K. Brown 301-286-5795

The Goddard Space Flight Center (GSFC) Parts Branch operates a nuclear particle calibration facility consisting of a 2 MeV Van de Graaff and a 250 keV electrostatic accelerator. The facility provides particle energies from 50 eV to MeV, and protons via reactions to approximately 20 MeV. Particle beams available range from electrons to Kr-84, with fluxes from approximately 1 particle/ sq cm sec. to approximately one billion particles/sq cm sec. Bremsstrahlung and X-ray lines can also be produced. It has been a unique facility in the world in this low-energy region. Some of its abilities are now duplicated up to 350 keV by an accelerator at Max-Planck Institute (MPI) Lindau. For several years, all work in this facility has been in support of magnetospheric and solar-terrestrial programs, although some X-ray work has been done for the Broad-Band X-Ray Telescope (BBXRT). Over the past 5 years, machine time has been split fairly evenly between calibration and testing of satellite experiments, testing and development of new particle detector systems, and sounding rocket payloads. Machine usage in the previous 13 months has increased to about 71 percent of full working weeks. The machines were operated at least one per week for more than 46 weeks during the last year, excluding maintenance, but including set up for incoming instruments, etc.

W88-70380 **442-36-58**
Goddard Space Flight Center, Greenbelt, Md.
THEORETICAL STUDIES AND CALCULATION OF ELECTRON-MOLECULE COLLISION PROCESSES RELEVANT TO SPACE PLASMA PHYSICS
A. Temkin 301-286-8091

The objective of this RTOP is to do calculations of electron-molecule scattering, primarily vibrational and rotational excitation of molecules of atmospheric (terrestrial and planetary) importance and also astrophysical utility in the general category of space (plasma) physics. The ultimate aim is to calculate collision cross section with N2, O2, and CO. Under present investigation is e-N2 scattering, of obvious atmospheric relevance, specifically the vibrational excitation of N2, which is important in understanding the secondary photoelectron flux and the electron heating rate in the ionosphere. N2 is also a chief constituent of the atmosphere of Titan and the excitation cross section is expected to be important in understanding its spectral features. We shall next consider the CO molecule. CO is the second most abundant molecule (after H2) in the galaxy. Since H2 is invisible and since CO tracks H2 and (via its $J=1$ to 0 transition) is visible at intergalactic distances its excitation mechanisms are important in understanding aspects of the interstellar medium. Collisions with electrons are expected to be important on the interface between H2 and H II regions. Finally we shall calculate e-O2. This cross section is vital to the understanding of many atmospheric terrestrial phenomena. O2 is also an important constituent (together with CO) of the atmosphere of Venus.

Sounding Rockets--Solar Terrestrial

W88-70381 **445-11-36**
Goddard Space Flight Center, Greenbelt, Md.
SOUNDING ROCKETS: SPACE PLASMA PHYSICS EXPERIMENTS
James P. Heppner 301-286-8797

The objective is to perform measurements and experiments that will lead to an understanding of the interactive processes that occur between neutral gases, plasmas, energetic particles, and electric fields in the atmosphere, ionosphere, and near-earth magnetosphere. Sounding rockets provide the only access for in situ measurements in the lower ionosphere (altitudes below 200 km) and middle atmosphere regions (30 to 90 km). Emphasis is also placed on measurements and experiments that utilize the unique characteristics of sounding rocket trajectories and/or the low cost, quick reaction sounding rocket approach which permits program flexibility. Historically, this approach has logically been extended to include: (1) piggyback experiments on orbiting vehicles; (2) experiments involving sounding rocket flights in association with simultaneous satellite measurements in selected geometrical coincidence between trajectories; (3) flight testing of new instrumentation and measurement techniques; (4) shuttle flights of low cost, rocket type payloads; and (5) investigations of the electrodynamics of middle atmosphere (i.e., below 90 km) using sounding rockets for deploying payloads which descend via parachutes.

W88-70382 **445-11-36**
Marshall Space Flight Center, Huntsville, Ala.
NON-EQUILIBRIUM SPACE PLASMA INSTRUMENTATION SRT (DIFFERENTIAL ION FLUX PROBE DEVELOPMENT)
N. H. Stone 205-544-7642
(442-20-01)

The objective of this RTOP is to evaluate plasma diagnostic techniques and develop space plasma instrumentation capable of diagnosing highly non-equilibrium plasmas in the near environment of space vehicles. The related RTOP, Plasma Flow-Space Plasma Electrodynamics, involves supporting laboratory plasma investigations and flight data analysis. The scientific instrumentation development under this RTOP is required for the Centaur sounding rocket experiments (funded under RTOP 445-31-36-46). Three tasks are required to accomplish this objective: (1) continued development of the Differential Ion Flux Probe (DIFP); (2) development of a high throughput mass analysis technique; and (3) development of a combined ion mass and flux vector sensor. The proper and unambiguous diagnosis of non-equilibrium plasmas is essential to the success of future active space plasma experiments and a proper interpretation of space plasma data, in particular data from sounding rockets and satellites immersed in regions of active particle ionization. This effort to extend the state of the art of space plasma instrumentation is directly related to ongoing NASA sounding rocket programs, space plasma physics space shuttle missions, future NASA planetary and cometary probes, and DOD space test program flights.

W88-70383 **445-31-36**
Wallops Flight Center, Wallops Island, Va.
SUPPORT OF OUTSIDE INVESTIGATORS
L. J. Early 804-824-1611

This is a pass-through arrangement for the Space Plasma Physics Office (EES), Earth Science and Applications Division, Office of Space Science and Applications to transfer monies to approved grantees. A research and technology resume for each separate grant will be prepared by EES and reviewed in the Headquarters Program Review. The objective is to provide a more streamlined administrative system for transferring monies to various science experimenters within universities and industry with approved grants or contracts for plasma physics experiments leading to a better understanding of the interactive processes of gases, particles, and fields in the atmosphere, ionosphere, and magnetosphere. Individual funding is accomplished upon approval of the research effort by the NASA Headquarters Science Discipline Chief. Emphasis is placed on studies which utilize sounding rockets to provide the platform for data collections. It is NASA policy to foster and encourage the submission of unsolicited proposals relevant to agency mission requirements. When an unsolicited proposal contains unique, innovative ideas, scientific merits, potential contribution to the agency, and receives a favorable technical evaluation, a specific grant is approved by the NASA Headquarters Science Discipline Chief. Space Plasma Physics (EES) currently has 28 ongoing grants which are administered through the Wallops Flight Facility Sounding Rocket and Balloon Projects Office.

Space Station Integrated Planning

W88-70384 **450-11-00**
Marshall Space Flight Center, Huntsville, Ala.
SCIENCE OPERATIONS
H. G. Craft 205-544-5418

The efforts under this RTOP will be to conduct studies of space station integration, operations planning, and in-space development construction and testing of scientific equipment. Historical experience in spacelab integration and operations will be applied to the space station development.

W88-70385 **450-11-00**
Goddard Space Flight Center, Greenbelt, Md.
PROGRAM SCIENCE OPERATIONS
Philip J. Cressy 301-286-2030

The objectives of this task are to establish and analyze user requirements for operating experiments on Space Station, and to promote these requirements in Science and Applications Information System (SAIS) and related information system planning and test bedding. The approach is to analyze specific projected Office of Space Science and Applications (OSSA) experiment scenarios and requirements, to develop and validate science operations concepts and generic experiment scenarios, and to develop experiment operations and management plans and procedures. Special studies will examine critical life-cycle operations issues. Results will define operations test bedding requirements, and will be translated into system functional and service requirements.

W88-70386 **450-11-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
UTILIZATION OF THE SPACE STATION FOR SOLAR SYSTEM EXPLORATION MISSION STAGING
Robert L. Staehle 818-354-1176

The overall objective of this activity is to assist the Office of Space Science and Applications (OSSA) in preparing for the most productive possible implementation of Solar System exploration (SSEx) missions once the Space Station is in operation. Various mission types will have been examined during FY87, including a Mars Rover and Sample Return (MRSR), Comet Nucleus Sample Return (CNSR) and possible future missions with greater earth departure mass. One mission type that appears particularly suited to staging through Space Station will be selected for a detailed case study development. Under this RTOP the operations requirements of the selected mission will be formulated in detail and compared with the resources, operations, accommodations and ground facilities presently envisioned for Space Station. Areas of mismatch between the SSEx mission and present Space Station plans will be identified and used to generate inputs to the Space Station requirements process and operations planning. Activities under this RTOP will be closely coordinated with JPL work for Code S on Space Station operations and accommodations definition, policy formulation, automation and other areas.

W88-70387 **450-11-02**
Ames Research Center, Moffett Field, Calif.
SPACE STATION LIFE SCIENCES OPERATIONS
R. D. Arno 415-694-6640

The purpose of this RTOP is to integrate Space Station Life Sciences Research Facility (LSRF) activities to ensure a smooth progression of the many activities necessary to conduct Life Sciences research aboard the Space Station. The Science Operations Program is responsible for the definition and development of operational techniques and technology required to implement and facilitate life sciences research on the Space Station. These responsibilities encompass evaluating the overall operations requirements of Space Station life sciences research including crew and systems data, utilities, and other resources, logistics support, inventory control, supplies, waste management, bioisolation, contamination control, experiment protocols, ground facilities and support. This also includes operations at all locations, and activities at ARC and at launch and recovery sites, Payload Operations Control Center (POCC) operations, investigator interfaces, ground control, crew training, mission scenario development, crew timelines, etc. Computer simulation programs, models, mockups, and test beds will be developed as necessary to evaluate operational concepts. The results of the simulation programs, mockup activities and test beds will be incorporated into the flight hardware design concepts; however, actual construction of flight hardware is not within the scope of this RTOP.

W88-70388 **450-12-00**
Goddard Space Flight Center, Greenbelt, Md.
SAIS SYSTEM ENGINEERING
Philip J. Cressy 301-286-2030

The objectives of this task are to analyze science user requirements for operations services, to define system requirements to provide these services, to explore system concepts and approaches to meet these requirements, and to develop an end-to-end Office of Space Science and Applications (OSSA) information system architecture. Results are also provided to Space Station Information System planning and concept development. The Science and Applications Information System (SAIS) Architecture Working Group has been established to pursue these objectives. The working group selects information system topics critical to science operations, explores them in depth, subjects proposed concepts to broad review, and prepares white papers to disseminate resulting SAIS system concepts. Experimental activity to test and validate system concepts is recommended to the SAIS test bed program. Review and proposal of changes to baselined Space Station plans and concepts are also part of working group activity.

W88-70389 **450-12-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SCIENCE AND APPLICATIONS INFORMATION SYSTEM (SAIS) SYSTEMS ENGINEERING
R. B. Pomphrey 818-354-3890
(450-17-01; 450-14-01)

The task contained in this RTOP will be carried out in support of the Space Station Integration Office (SSIO) Science and Applications Information Systems (SAIS) Effort. Detailed engineering is to be carried out by each of the four SAIS working group panels. Phase A study will be completed by early calendar year 1988, with Phase B study lasting from 1.5 to 3.0 years. The objective of this task is to accomplish the systems engineering of the SAIS. The approach to be followed for this task is as follows: (1) participate in the systems definition and engineering work of the SAIS Executive Steering Group; (2) participate in and support the activities of the SAIS Panels: SAIS Panel 1 (End-To-End Connectivity), SAIS Panel 2 (Teleoperations), SAIS Panel 3 (Science Data Management), and SAIS Panel 4 (Teledesign); (3) draft the SAIS External Requirements Document; (4) integrate Consultative Committee for Space Data Systems (CCSDS) Standards efforts into SAIS Systems Engineering; (5) maintain cognizance of the SAIS User Requirements Document; (6) participate in the formulation of an SAIS Phase B Development Plan; and (7) participate in the SAIS Testbed Systems Engineering effort.

W88-70390 **450-12-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE STATION SOFTWARE REQUIREMENTS ANALYSIS
M. McKenzie 818-354-2577
(656-20-02)

The purpose of this RTOP is to support the Office of Space Science and Applications (OSSA) in reviewing Space Station software development tasks, such as the Software Support Environment (SSE), the User Support Environment (USE), the Technical and Management Information System (TMIS), and related areas. This support will be coordinated with the Code E

representative from HQ and any issues or concerns pertaining to this area will be coordinated with the Science and Applications Information System (SAIS) Working Group for resolution. The major objectives are: (1) provide a coordinated review of Space Station software plans and documents from an OSSA and JPL user perspective; (2) provide representation of potential OSSA and JPL users on Space Station software advisory boards and working groups; and (3) identify major issues and pursue resolution with the appropriate user communities. In accomplishing the above objectives, this RTOP will support a representative of JPL and OSSA who will participate in the Software Support Environment Users Working Group, the User Support Environment Working Group, the SAIS Working Group (Panel 4), and relevant Level 3 Control Boards and other relevant committees as they arise. User needs and concerns will be collected and provided to these bodies. The group output and products of the above software efforts will be reviewed, and interfaces with other relevant Space Station activities will be coordinated. Issues important to OSSA and JPL will be identified and resolved.

W88-70391 **450-12-02**
Goddard Space Flight Center, Greenbelt, Md.
ON-LINE ACQUISITION AND ANALYSIS OF HOLOGRAPHIC INTERFEROGRAMS OF SPACE STATION STRUCTURAL MATERIALS AND COMPONENTS
Walter Viehmann 301-286-8970

The objective of this RTOP is to develop a Holographic Interferometer, with microprocessor controlled data acquisition and computer aided analysis to facilitate flaw detection in structural components. A major reason for the limited acceptance of holographic non-destructive evaluation by industry is the complexity of interpreting holographic interferograms. This problem can be greatly alleviated by a system comprising a self-scanned photodiode array, microprocessor controlled data acquisition subsystem and a computer, or link, to a time-sharing computer.

W88-70392 **450-14-00**
Goddard Space Flight Center, Greenbelt, Md.
AUTOMATION AND ROBOTICS
Thomas LaVigna 301-286-8351

The objective of this RTOP is to provide users with the necessary guidelines from which to design and develop their hardware so that they can fully utilize the on-orbit assembly capability provided by the Space Station. These guidelines will cover the user requirements for hardware designs that will accommodate assembly of the user systems using automation and robotics. Definition of the on-orbit assembly capability and automated and robotic operations to accomplish that assembly will be of sufficient detail to serve as design drivers for user systems. From this definition, users will be able to identify the design details that will enable them to implement system designs that will utilize the unique capabilities offered by the Space Station.

W88-70393 **450-14-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AUTOMATION TECHNIQUES FOR SCIENCE MISSIONS
D. Atkinson 818-397-9521
(450-17-01)

The long-term objective is to develop capabilities which support the operations of remote science users. A major objective of this test is to develop and demonstrate technologies which enable and enhance the monitoring and diagnosis capabilities of ground data systems for unmanned spacecraft and their instrument payloads. A further objective is to develop tools which are commonly applicable to the automated monitoring and diagnosis of spacecraft telemetry as well as space flight operations ground data systems. The long-term task is divided into two principle steps: the development of an automated spacecraft telemetry monitoring workstation, and the application of this workstation to actual spacecraft subsystems in a demonstration parallel to actual operations. Artificial intelligence techniques for automated real-time monitoring of subsystem status and trouble-shooting would be developed and utilize advanced human interfaces. A major consideration in the design of the system will be the need to support remote science users and science operations in future extensions of the workstation. These added capabilities would include support for remote planning and scheduling of science activities on the spacecraft. Effective remote science planning and scheduling requires timely and complete information about the state of the spacecraft, available resources, the status of the instrument's health, and achievement of current observation of experiment goals. The initial effort in monitoring and diagnosis helps meet these requirements.

W88-70394 **450-15-00**
Marshall Space Flight Center, Huntsville, Ala.
SPACE STATION PRESSURIZED VOLUME UTILIZATION STUDY
Roy Lester 205-544-5424

These studies will develop plans for the outfitting of the Space Station pressurized volume. Use will be made of contractor expertise developed while performing integration functions for Spacelab payloads or related activities.

W88-70395 **450-15-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE STATION PAYLOAD DEVELOPMENT AND OPERATIONS CASE STUDIES
R. Staehle 818-354-1176

The objective of this activity is to assist the Office of Space Science and Applications (OSSA) in preparing for the most productive scientific utilization of the Space Station. A series of issues will be examined that affect the OSSA approach to design and operation of science payloads in the Space Station era. These issues concern both the requirements that OSSA must levy on the Space Station Program to accomplish OSSA objectives, and the requirements OSSA must levy on OSSA-sponsored payloads in order to interface with the Space Station system and organization. In part, this activity will draw upon various detailed Space Station payload interface and operations scenarios that have been developed or are under development with co-funding from Code S. By examining a spectrum of representative payloads for which well-developed concepts, designs, or actual hardware already exists, a range of critical issues will be illuminated, including those related to specific payloads, testbedding and simulation, operations using telescience, evaluation of Code S policies, procedures, resources to be provided, and the impact of these on OSSA payload operations. A result of these studies will be the development of operational constraints on payloads, and defining payload needs for Space Station Integration Office (SSIO) support. A portion of this activity will examine operations integration issues including multi-user interaction of OSSA-sponsored payloads and evaluation of alternative payload hosts such as free-flyers and platforms.

W88-70396 **450-15-00**
Goddard Space Flight Center, Greenbelt, Md.
PROGRAM TECHNICAL STUDIES/SUPPORT
Kenneth J. Frost 301-286-8824

The objective of this RTOP is to develop the technical data which will describe the interface compatibility, integration procedures, operations scenarios and logistics strategies for Office of Space Science and Applications (OSSA) payloads using the Space Station attached payloads facilities and the polar platform. This RTOP is complementary to and will be closely coordinated with RTOP's 450-11, 450-12, 450-14, 450-16 and 450-17.

W88-70397 **450-15-02**
Ames Research Center, Moffett Field, Calif.
SPACE STATION PAYLOAD ANALYSIS AND TRADE STUDIES
D. N. Rasmussen 415-694-6603

The technology requirements associated with candidate Space Station experiments are being evaluated to ensure that the appropriate equipment is available for flight. This RTOP serves the function of technology development management and coordination by synthesizing Space Station technology requirement

inputs, trade-off analysis, and identifying generic critical technologies. Technology requirements will be identified through the continued assessment of OSSA goals and the evolving list of typical Space Station experiments. Equipment priorities will be identified and critical technology requirements will be tabulated and assessed for availability, complexity, development status, and technological risk. Supporting research and technology (SR and T) goals, costs, and schedules will be developed for the needed proof of concept research and development (R and D). Particularly important technologies will be recommended for development.

W88-70398 **450-16-00**
Goddard Space Flight Center, Greenbelt, Md.
SCIENCE MISSION STUDIES
Kenneth J. Frost 301-286-8824

This RTOP will support investigators studying several types of payloads which are potential candidates for implementation on the Space Station in the near term as well as in the evolutionary phase. Each of the studies will provide a scientific discussion of the merits of the payload, a detailed technical assessment of the unique advantage to science of implementing the payload on the Space Station, specifications of the interface and operating parameters required of the Space Station by the payload and a proposed implementation schedule. The types studied will include payloads which are in an advanced state of development and which could be used to inaugurate the era of Space Station science (pathfinder payloads), payloads which are uniquely enabled by the capabilities of the Space Station and payloads which require assembly on-orbit.

W88-70399 **450-16-00**
Marshall Space Flight Center, Huntsville, Ala.
SCIENCE MISSION STUDIES
Carmine E. DeSanctis 205-544-0618

Various Space Station science mission studies will be conducted relating to the following: (1) requirements for and definition of lab support equipment within the U.S. Laboratory; (2) user community needs for rapid sample return capability for the Space Station; (3) contaminant requirements and development of a continuous contamination monitor to fly on a future Spacelab mission; and (4) concepts for the verification of deployment and assembly of large precision structures on the Space Station.

W88-70400 **450-16-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL COMMUNICATIONS AND NAVIGATIONAL TRACKING STATION DESIGN FOR SPACE STATION
James R. Lesh 818-354-2766

The objective of this RTOP is to design, and determine the interfaces for, an optical communications reception and navigational tracking station on the Space Station for supporting anticipated Code E sponsored missions of the future. The RTOP will first formulate and analyze the systems requirements for a typical mission set scenario, translate those systems requirements into a set of station design requirements, and then proceed on a set of station design studies. Interface requirements with the Space Station as well as overall operational concepts and scenarios will be identified from the design studies.

W88-70401 **450-16-02**
Ames Research Center, Moffett Field, Calif.
SPACE STATION LIFE SCIENCES ENABLED SCIENCE
R. D. Arno 415-694-6640

The purpose of this RTOP is to ensure that Space Station life science research facilities meet the needs of the scientific community, and make maximum use of this national resource by providing the widest possible latitude of science experimentation. Extensive studies, workshops, and interactions with the science community are required to gather, collate, and synthesize user requirements to influence life science facilities and Space Station engineering and operational philosophy. This RTOP will, through the use of workshops and studies, oversee and integrate science input requirements to guarantee a cohesive and consistent scientific approach. Experiment descriptions will be generated where necessary to ensure accurate identification of equipment and experimental consistency of approach to bioisolation, equipment sharing, contamination, vibration and g-load disturbance, approaches to accommodations (e.g., generic facilities vs. investigator specific, cage size, gravity gradients, etc.), and international science implications.

W88-70402 **450-16-12**
Ames Research Center, Moffett Field, Calif.
HUMAN-RATED CENTRIFUGE STUDY
L. G. Lemke 415-694-6531
(199-90-67)

The objective of this RTOP is a preliminary mission and system definition for a space-based human-rated centrifuge to function as an Artificial Gravity Research Facility (AGRF) and identification of precursor technology development activities, including both ground and space based experiments. The AGRF will become operational during the post-Permanent Manned Configuration (PMC) phase of the Space Station and may be enabled or significantly enhanced by operating attached or in close proximity to the Station. The primary mission of the AGRF will be to conduct basic and applied life sciences research with particular emphasis on the effects of variable gravity, partial gravity, and rotating reference frames on human subjects. The approach for this RTOP is to: (1) define the technical and programmatic requirements for an AGRF; (2) identify and define major technical system options and trade-offs by performing definition studies; and (3) identify significant technology developments required and propose experiments to achieve them.

W88-70403 **450-17-00**
Goddard Space Flight Center, Greenbelt, Md.
SAIS TESTBEDDING
Philip J. Cressy 301-286-2030
(450-11-00)

The overall objectives of testbedding are to test end-to-end information systems concepts and their applications for the purposes of establishing Science and Applications Information System (SAIS) requirements, define SAIS functional architectures, and validate approaches to meeting science operations requirements. The particular goals of this RTOP are to test advanced science data management concepts, with emphasis on expert systems and artificial intelligence, and to develop and test a distributed operations scenario for a simulated Space Station astrophysics mission. The approach to the data management task will be to develop and test an automated data ingest design, utilizing existing data management systems and capabilities at GSFC. The data base access task will design, establish and test two interdisciplinary data bases, using view integration methodologies developed previously at GSFC. The standard format data unit (SFDU) task will develop and test software to extract SFDUs from a file and to prepare meta-data and science data for use by an external application program. The expert analysis system task will focus on application of current knowledge-based techniques to design and prototype development of a goal-directed image data analysis system. The approach of the astrophysics simulation task is to develop a remotely accessible mission simulation scenario for testing distributed operations approaches. The approach of the Tracking and Data Relay Satellite (TDRS) gateway task is to develop a transmission formatting technique to integrate and deliver efficiently a mixed set of communication types and bandwidths.

W88-70404 **450-17-00**
Marshall Space Flight Center, Huntsville, Ala.
TESTBEDDING FOR TELESCIENCE
H. F. Kurtz 205-544-2007

MSFC will conduct testbed activities in the areas of microgravity operations, video data handling, operations planning and scheduling, remote user access, and teleoperations. This work will be done in collaboration with university participants and international partners developing the concepts for shared utilization

and mission planning. MSFC will utilize existing Spacelab payload operations capabilities (e.g., Payload Management Information System, Payload Operations Control Center, Payload Crew Training Complex, Mission Integration Planning System, SPAN), develop modifications simulating prototype Space Station techniques, and conduct tests with remote users of Space Station operating concepts. Tests will include: (1) distributed mission planning techniques demonstrating remote user interaction and expert system software; (2) alternative modes of remote user data/command/planning comparing low cost parasitic Payload Operation Control Center (POCC) workstations and user-provided processing systems; and (3) definition of typical discipline user interface scenarios.

W88-70405 **450-17-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SCIENCE AND APPLICATIONS INFORMATION SYSTEM (SAIS) TELESCIENCE TESTBED
B. Anderson 818-354-0896
(450-12-01; 450-14-01)

Design and development of data and information systems for the support of science investigations in the space station era involves an order of magnitude increase in complexity and performance beyond current capabilities for both instruments and data systems. In this environment the traditional methodology of fully defined systems requirements followed by design and implementation in a sequential manner carries very high risk. To meet the needs of the space station era science support, especially for high rate instruments, requires an approach in which key tall pole elements identified in the requirements phase are demonstrated and evaluated in prototype technology developments and technology testbeds and the results used to re-evaluate requirements and design. A close integration between systems engineering design teams and working groups and the testbed must be maintained so that proper prioritization of needs and utilization of testbed of results are maintained. This RTOP begins to address elements of technologies and systems concepts in the area of instrument planning and scheduling and high rate instrument control which will support teleoperations and telescience modes regarded as essential to support long-term investigations by teams of remote investigators. Collaboration with other NASA Center, university and international partners is an essential element of the approach to development of the teleoperations concept.

W88-70406 **450-17-02**
Ames Research Center, Moffett Field, Calif.
TESTBEDDING FOR TELESCIENCE, TELEOPERATION, AND TELEDESIGN
D. N. Rasmussen 415-694-6603

The objective of this RTOP is to support and evaluate testbed activities in the area of network interoperability. Some testbed activities have been developed to demonstrate that existing capabilities can support telescience, teleoperation, and teledesign for Office of Space Science and Applications (OSSA) research. By involving potential users from all OSSA scientific disciplines in the early use of these advanced hardware/software concepts and new methods of operation, a better definition of payload requirements and specifications will result. The approach is to use existing facilities at various universities and participating NASA centers, which are interlinked through a common communication network. This will allow rapid prototyping of advanced concepts and technologies and evaluation of those concepts by potential users. In order to provide an infrastructure for supporting experiments using geographically separate institutions, existing facilities will be modified, where appropriate, to provide commonality and ease of use.

Technical Consultation and Support Studies

W88-70407 **643-10-01**
Lewis Research Center, Cleveland, Ohio.
SPECTRUM AND ORBIT UTILIZATION STUDIES
J. W. Bagwell 216-433-3502

Technical consultation services support will be provided in the area of space communication services with particular emphasis on preparing for international meetings relating to the fixed-satellite service (FSS), the broadcast-satellite service (BSS), and the mobile-satellite service (MSS). The technical basis and regulatory support needed to obtain sufficient orbit/spectrum to meet current and projected requirements of NASA and the United States will be provided. Researchers will perform studies, develop analytical methods for spectrum management, conduct evaluations, identify technology status and needs, perform critical technology developments, perform measurements (where necessary) to determine sharing criteria, and evaluate alternatives that result in efficient and cost-effective use of the geostationary orbit/spectrum resource. Specifically, these activities will support domestic and international preparations for the 1988 Space Services World Administrative Radio Conference (WARC) with primary emphasis on the FSS, and secondary emphasis on the BSS and the MSS. The activities will also support domestic and international MSS planning in the 806 to 890 MHz band. The described activities will be conducted within the framework and schedules of the applicable International Radio Consultative Committee (CCIR) Study Groups, the special preparatory committees established in the United States, and the national and international meetings called to support preparations for the conferences. Efforts planned are a combination of in-house and contract activities.

W88-70408 **643-10-03**
Lewis Research Center, Cleveland, Ohio.
PROPAGATION STUDIES AND MEASUREMENTS
James W. Bagwell 216-433-3502

Propagation effects in earth-space-earth communication systems must be understood in order to reliably specify and design such systems. The Propagation Studies and Measurements Program provides the focal point for national activities which support NASA's applications program, development of prediction models, methods of compensation, orbit and spectrum use decisions, system specification and performance criteria related to space communication. The objectives of the NASA Propagation Studies and Measurements Program are to provide understanding, methods of analysis, and reliable techniques for compensation of the propagation effects which hinder earth-space communications. These objectives are accomplished by making use of existing satellites (such as MSAT-X, ACTS and leased Ku-band) as well as simulated satellites (aircraft, helicopters, balloons, towers, etc.) to obtain the necessary data for development of predictive models for confidently describing the performance of satellite communication systems where significant statistical fluctuation of signal power is expected; and to provide methods of statistically describing the performance of such systems. Objectives are also accomplished by participation in the work of the International Radio Consultative Committee (CCIR), in preparation for World or Regional Administrative Radio Conferences (WARCs or RARCs).

W88-70409 **643-10-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROPAGATION STUDIES AND MEASUREMENTS
Faramaz Davarian 818-354-4820
(643-10-05; 650-60-15)

The objective of the Propagation Studies and Measurements Program is to support NASA's Communications Division through studies and experiments regarding the propagation effects in earth-space systems. The propagation effects in the earth-space environment must be understood and accounted for in the design and specification of space communication systems. Therefore, the goals of this RTOP are to quantify the propagation effects through direct or simulated experiments (field tests), develop prediction models for cases where no experimental data exist, and provide support to the International Radio Consultative Committee (CCIR) and regulatory bodies. The objective of this RTOP is accomplished

through a work plan consisting of three types of activities: (1) propagation measurements and experiments from about 0.5 GHz to the optical frequencies; (2) analysis and modeling of propagation effects; and (3) propagation assessment of communication techniques and evaluation of propagation models. The first objective involves flight experiments or their simulation. This activity is conducted through field tests as well as participation in the Mobile Satellite Experiment (MSAT-X), the Advanced Communications Technology Satellite (ACTS) experiment, and other experimental programs. The second is conducted with the analysis and comparison of the results from the first with other data bases, and the publication of the results. Simulation and modeling efforts are included in this activity. The third is typically CCIR contributions, surveys, and the propagation handbooks for earth-space paths. This year, there will be an increased emphasis on collaboration and information exchange with domestic and international laboratories with an interest in propagation studies. The tasks of this RTOP will be carried out primarily at universities and government laboratories.

W88-70410 **643-10-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED STUDIES
A. Vaisnys 818-354-6219
(650-60-15; 643-10-03)

The objectives of this RTOP are to provide studies of system concepts leading to the growth of advanced communications satellite system services and to ensure the compatibility of NASA's communications flight programs with other space and terrestrial services. The technical objectives of this RTOP for FY88 are to continue system concept design and analyses on integrated aeronautical, maritime and land mobile satellite system, and satellite based small terminal communications and interactive data networks. With the key NASA communications satellite projects such as Advanced Communications Technology Satellite (ACTS) and Mobile Satellite Experiment (MSAT-X) progressing, this RTOP will examine advanced system concepts to be developed into full-scale technology projects and will be coordinated with MSAT-X project and related RTOPs. Areas of study are multiservice/multifrequency satellites and platforms and satellite based small terminal communications and interactive data networks. For the integrated aeronautical, maritime and land mobile satellite system, subjects of study include functional and operational requirements of each service, frequency sharing techniques, system design issues to meet substantially different requirements such as per-channel equivalent isotropically radiated power (EIRP), channel assignment time, security requirement, Doppler compensation, data quality, channel condition, etc. For small terminal communications and interactive data networks, the main thrust will be exploring the technology required for exploiting the high frequency bands for low data rate, including personal, communications. Existing small customer premises terminal technology will be examined and the technology cost drivers for systems using the high frequency bands for low data rate communications will be identified.

W88-70411 **643-10-05**
Lewis Research Center, Cleveland, Ohio.
ADVANCED STUDIES
J. W. Bagwell 216-433-3502
(650-60-20; 650-60-21; 650-60-22; 650-60-23; 643-10-01)

The objective of this RTOP is to establish the requirements/rationale and provide a focus for NASA's communications technology program consistent with the overall goals, objectives and thrusts of NASA's Communications Applications Program and to support appropriate initiatives in the Federal Communications (FCC), Interdepartmental Radio Advisory Committee (IRAC), International Radio Consultative Committee (CCIR), or International Telecommunications Union (ITU) for new space communications applications. The approach is to conduct in-house and contracted studies to: (1) assess current and future commercial, NASA, and other government telecommunications needs and opportunities; (2) assess applications, concepts and configurations to meet those needs and opportunities; (3) define technology developments and experiments needed to enable/realize new or enhanced space communications applications and systems; and (4) define and develop advocacy for suitable advanced communications technology development programs and experiments to be undertaken by NASA. The output from these studies will be used to address the technical, economic and institutional/regulatory feasibility of operational systems, and develop plans for guiding future communications technology development.

Advanced Communications Research

W88-70412 **650-60-15**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MOBILE COMMUNICATIONS TECHNOLOGY DEVELOPMENT
William Rafferty 818-354-5095
(643-10-01; 643-10-03; 643-10-05)

This RTOP describes an on-going technology development program aimed at efficient utilization of orbit, spectrum and equivalent isotropically radiated power (EIRP) for future generation mobile satellite systems (MSS). Previously there were five major areas of technology concentration. This has been increased to six with the addition of a Large Antenna subtask which, in the past, had been a low level effort. The Large Antenna effort is a planned step in the process to study and respond to space segment MSS requirements. The technology areas are: (1) vehicle antennas, where the objective is to develop mechanically and electronically low profile, steerable antennas which provide a moderate gain (10 dBic) and through directivity provide sufficient isolation as to permit multiple satellites to operate in the same frequency band without mutually interfering; (2) digital speech coders, where the objective is to develop digital speech coders which can produce commercially acceptable voice quality with low complexity realizations at a 4800 bps rate; (3) digital modem, where the goal is to develop bandwidth and power efficient modulation and demodulation (modem) techniques which can support the above digital voice encoding schemes in a 5 kHz, satellite fading channel; (4) networking, an activity undertaken to investigate multiple access and network management protocols standards which efficiently utilize the resources of an integrated voice and data mobile satellite network; (5) channel characterization, a task directed at characterizing the mobile satellite channel through propagation experiments and modeling; and (6) large antennas, an effort aimed at developing the required technologies and test methodologies for multiple-beam spacecraft antennas compatible with the above vehicle antennas to enable increased MSS capacity by frequency re-use and orbital efficiency. Much of this technology is applicable to space science missions, e.g., astrophysics and remote earth sensing, and advanced MSS concepts including Personal Communications. The above activities are accomplished through in-house JPL efforts and a mix of industry and university contracts. A series of field experiments has been initiated, and will be continued, to validate the system concepts and operational equipment being developed. As the above technologies are developed and validated, they will be phased into the evolving mobile satellite network and indeed are accelerating its initial introduction.

W88-70413 **650-60-20**
Lewis Research Center, Cleveland, Ohio.
SPACE COMMUNICATIONS SYSTEMS ANTENNA TECHNOLOGY
James W. Bagwell 216-433-3502
(650-60-22)

The objective of this RTOP is to conduct research and technology development on antenna systems and components for advanced space communication systems. Previous efforts have resulted in design, fabrication and testing of antennas and components based on both conventional and MMIC technologies. Current efforts will involve the study, design, fabrication and testing

of advanced systems using monolithic microwave integrated circuit (MMIC) devices for applications requiring increased performance and/or reduced weight and power costs. Requirements for future systems and critical device/component technologies will also be assessed. The emphasis will be on exploiting MMIC device technology for arrays where impact is both desirable and feasible in the near term and on investigating the future use of light wave technology in array feeds and arrays.

W88-70414 **650-60-21**
Lewis Research Center, Cleveland, Ohio.
SATELLITE SWITCHING AND PROCESSING SYSTEMS
James W. Bagwell 216-433-3502
(650-60-20; 650-60-22; 650-60-23)

The objective of this RTOP is to conduct research and technology development of components and subsystems for advanced communications satellite systems in the area of on board message switching and processing, modems, codecs, and cost efficient implementation of earth terminal subsystems. Work focuses on the full range of spaceborne, ground and network control and management systems. Work under the RTOP is performed primarily under aerospace communications industry contracts and a portion through university grants. Work includes focused and proof-of-concept (POC) advanced technology development for: (1) fault tolerant baseband processing; (2) matrix switching; (3) bandwidth efficient combined modulation and coding concepts; (4) high speed, low power GaAs enabling components; (5) adaptable modems; (6) bulk demodulator/decoders; (7) power and bandwidth efficient high speed codecs; and (8) on board master control.

W88-70415 **650-60-23**
Lewis Research Center, Cleveland, Ohio.
COMMUNICATIONS LABORATORY FOR TRANSPONDER DEVELOPMENT
James W. Bagwell 216-433-3502
(650-60-20; 650-60-21; 650-60-22)

The objectives of this RTOP are to design and develop a laboratory test facility to be used to test communication system components and subsystems, and to provide laboratory simulations of multibeam satellite communications systems; and to further develop prototype ground terminal systems for use with the Advanced Communications Technology Satellite (ACTS) and other advanced communication satellites. The approach will be to design, develop, and test 30 GHz uplink, frequency translator and 20 GHz downlink communications system, including transmitting and receiving ground terminals, and satellite segment. Continuous bit stream rates of nominally 27.5 Mbps and 220 Mbps will be used to modulate the links. End-to-end calculations will be made. Software simulation results will be compared with the hardware simulation results. Upon completion, network control methods will be added and burst data transmissions will be tested and evaluated in both hardware and software. Specific testing in support of the ACTS Program including the development of High Bit Rate (HBR) ground terminal will be carried out.

Information Systems

W88-70416 **656-11-02**
Goddard Space Flight Center, Greenbelt, Md.
STANDARDS FOR EARTH SCIENCE DATA
James I. Vette 301-286-2864

The primary objectives of this work are to establish a standards program for the Earth Science and Applications Data System (ESADS) community, and to participate in the development of a reference model that will allow effective communication between individuals attempting to identify standards for increased interoperability between the various ESADS data systems. A Space Plasma Analysis Network (SPAN) accessible data base about appropriate standards will be assembled with information about the standards organizations, the standards themselves, and the standardization process for use by the ESADS community. The requirements for the ESADS Standards Secretariat will be developed, and a set of procedures for the ESADS standardization process will be recommended. The ESADS Reference Model group will generate a model, described through figures, terminology, and text, that identifies and isolates the major functions of Earth Science and Applications data systems. Starting with the American National Standards Institute (ANSI), the International Standards Organization (ISO), the National Bureau of Standards (NBS), and the Consultative Committee for Space Data Systems (CCSDS), appropriate material will be obtained, and a data base will be designed and installed on the most appropriate existing database management system (DBMS) available at the National Space Sciences Data Center (NSSDC). Information on this material, and others identified in the process, will be entered into the data base. Inputs to the data base will be made on a continuing basis. Based on discussions with existing secretariats, procedures to carry out the standardization process within ESADS will be drafted, and the requirements for NSSDC to carry out the secretariat role will be defined. NSSDC will participate in the ESADS model group and provide modeling materials and perspectives, gained from CCSDS work, as a starting point for model development. These materials will be extended to cover the functionality of directory and catalog interoperability, data ingest and retrieval, display, interpretation, and common user interfaces. The resultant model will be compared with existing ESADS systems to ensure adequate modeling of the major system functionalities.

W88-70417 **656-11-05**
Goddard Space Flight Center, Greenbelt, Md.
DATA STORAGE MEDIA
Barbara E. Lowrey 301-286-4995

This new RTOP is to provide for evaluating and exploiting optical media and other data storage media for the benefit of the National Space Sciences Data Center (NSSDC) and its user communities, and to develop applications of the media to data storage problems. The fiscal 1988 plans include: (1) to purchase equipment to premaster tapes into CD-ROM form, which is to service NASA users; (2) to support the SOAR software enhancements as necessary to support users interfacing optical drives to VAXes and MicroVAXes; (3) to develop a suite of software to provide uniform access to disks written under various operating systems; (4) to serve as an information collection and distribution resource for working groups on optical media; and (5) to develop a program plan to test WORM media for evidence of deterioration. The NSSDC will stay abreast of mass storage media developments as the technologies evolve.

W88-70418 **656-11-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIGH RATE HIGH VOLUME TECHNOLOGY
D. Nichols 818-354-8912
(656-55-02)

Space-based scientific instruments of the future will produce increased amounts of data over the life of a mission as a result of higher average data rates and higher peak data rates. Imaging instruments, both radar and optical, are typically the largest data producers. Several such instruments for the earth sciences are expected to be in operation in the EOS era, such as the Synthetic Aperture Radar, and both high and moderate resolution imaging spectrometers. Existing instruments (e.g., Landsat Thematic Mapper and Advanced Very High Resolution Radiometer or AVHRR) and those expected to be operational in the next several years such as Spaceborne Imaging Radar C (SIR-C), Airborne Visible and Infrared Imaging Spectrometer (AVIRIS), Earth Resources Satellite 1 (ERS-1), and Synthetic Aperture Radar (SAR) also have extremely high data rates. These kinds of instruments present special data system challenges in providing timely scientific data, processed to the appropriate level at a reasonable cost. The objective of this RTOP is to develop capabilities in selected information system areas, complementary with other NASA activities, which will provide the science user more convenient and timely access to large data bases and the tools for combining

and analyzing the data. The end goal of the individual tasks will be actual software and hardware which can be provided to the earth science data system community to address bottlenecks in the data delivery system. Three specific tasks are proposed for FY88: (1) SAR data compression for data storage and communication; (2) evaluation of high speed networks for ground data system interconnection as well as end user data delivery; and (3) multi-sensor data registration for use in correlative data analysis. These tasks will be coordinated with other centers and universities through the necessary working groups (such as that proposed by the Earth Science and Applications Data System (ESADS) Committee to address User Environment Bandwidth).

W88-70419 **656-13-02**
Goddard Space Flight Center, Greenbelt, Md.
EARTH SCIENCE AND APPLICATIONS DATA SYSTEM ACTIVITIES
Robert D. Price 301-286-9041

The objective of this RTOP is to enhance or enable capabilities of data/computer systems which are used by the Earth Science and Applications scientific research community. Action Statements were generated at the February 1987 Earth Science and Applications Data Systems Workshop which focused on near-term (1 to 3 years) improvements in Earth Science and Applications data/computer systems. The action statement pertaining to the National Space Science Data Center and its inherent discipline data activities, the Goddard Image and Information Analysis Center and its Image Analysis and massively parallel processing (MPP) Facilities, and the Data Flow Technology Office and its local and wide area network responsibilities will be accomplished through the emplacement of new technology, implementation/changes of procedures, increases in services, and development of new capabilities.

W88-70420 **656-13-40**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NASA OCEAN DATA SYSTEM: TECHNOLOGY DEVELOPMENT
J. C. Klose 818-354-5036
(161-40-10)

The objective of the NASA Ocean Data System (NODS) is to archive and distribute data sets from spaceborne ocean viewing sensors and, to a limited extent, data sets from in-situ measurement systems. NODS will provide a catalog of data sets relevant to ocean science that can be interrogated interactively. Interactive access will be provided to a bibliography system which provides abstracts of documents relevant to data sets referenced in the catalog or held by the archive. NODS will archive data at various processing levels, ranging from levels 0, 1, and 2 swath-oriented data to levels 3 and 4 gridded data. NODS will produce and archive browse products which are designed to provide rapid response to users wishing to browse through data interactively. Users will be able to select data by time, region, project, sensor, data level, and measurement. Selected data can be displayed at the user's terminal, electronically transmitted to the user or written to magnetic or optical media for shipment to the requester. NODS exists to serve the data needs of researchers in NASA's oceanography program and in the wider community of NASA-associated ocean research programs such as World Ocean Circulation Experiment (WOCE), Tropical Ocean Global Atmosphere (TOGA), and GOFS. NODS is a computer-based distributed system of archive and catalog nodes and user terminals or workstations, linked together by a computer network. NODS archive nodes contain data from NASA oceanographic spaceborne sensors, allied non-NASA oceanographic spaceborne sensors, and allied oceanographic in situ sensors. NODS, in the strict sense, refers to those components of the distributed system described above funded directly or indirectly by NASA. NODS may interface with other NASA disciplinary or interdisciplinary data systems (e.g., NCDS, CODD), data systems of other agencies (e.g., NOAA, NSF, USGS), and eventually may become integrated into an interagency ocean science or earth science data system. NODS may also develop network connections and data (or metadata) exchange standards and agreements with ocean-related data systems of other countries (e.g., Europe, Canada, Japan).

W88-70421 **656-13-50**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PILOT LAND DATA SYSTEM
E. D. Paylor 818-354-2867
(677-41-03; 656-13-40; 656-31-01)

The objective of the Pilot Land Data System (PLDS) project is to develop and implement a prototype state-of-the-art data and information system to support research in the land related sciences that will lead to a permanent research tool. The capability is to be general, inter-center, and be based, to the extent possible, on existing technology. This particular task will: (1) develop and implement JPL's portion of PLDS; (2) continue to support the PLDS technical areas for developing, testing, and maintaining the overall PLDS system; and (3) specifically ensure that the PLDS is responsive to the needs of the Sedimentary Basins Projects Science users. PLDS is a multi-NASA center activity led by GSFC. JPL personnel will participate in the PLDS Design and Science teams. Liaison and coordination with other ongoing projects, such as the Airborne Visible and Infrared Imaging Spectrometer (AVIRIS), High Resolution Imaging Spectrometer (HIRIS) data processing, Synthetic Aperture Radar (SAR) data processing, hypercube, Earth Observing System (EOS) data and information system, Science and Applications Information System (SAIS), and the other Pilots will be maintained. The PLDS will be developed in a way which provides early capabilities to the Land Surface Climatology and Sedimentary Basins Projects, while providing generic capabilities and techniques having a broader use. Science Requirements levied on the PLDS by these science projects will be used to functionally design and upgrade the system. Each system component will be developed in parallel with the science projects, thus providing maximum utility of each component during the development/testing phase of the project. JPL participation in PLDS follows the PLDS work breakdown structure established by PLDS Project Management.

W88-70422 **656-13-50**
Goddard Space Flight Center, Greenbelt, Md.
PILOT LAND DATA SYSTEM
Paul H. Smith 301-286-5876
(677-80-80)

The Pilot Land Data System program goal is to establish a prototype state-of-the-art data and information system to support research in the land related sciences which will lead to a permanent research tool. The approach is to develop a management structure and technical approach for a multicenter engineering development effort and to provide rapid prototyping and integration of existing systems to support the following land research activities: First International Satellite Land Surface Climatology Project (ISLSCP) Field Experiment (FIFE), ISLSCP Retrospective Analysis Program (IRAP), and the Sedimentary Basin Project (SBP), and to develop and implement advanced permanent systems supporting land science research.

W88-70423 **656-13-50**
Ames Research Center, Moffett Field, Calif.
PILOT LAND DATA SYSTEM (PLDS)
William Likens 415-694-5596
(656-42-01)

The objective of the Pilot Land Data System is to emphasize link-up of existing computer facilities currently used in land science data processing. This system would be built to explore issues in constructing a full-scale system for supporting all NASA land science data processing being carried out at NASA centers and associated universities. This work is managed by GSFC. ARC responsibilities are for establishment of a computer network, development of user documentation, and for appropriate system interface software and hardware. ARC is also responsible for development of the PLDS aircraft program data base node at ARC.

W88-70424 **656-20-26**
Goddard Space Flight Center, Greenbelt, Md.
MPP SOFTWARE AND USER SUPPORT
J. R. Fischer 301-286-3464

Beginning in the Fall of 1985, a pioneering team of 39 scientists, the Massively Parallel Processor (MPP) Working Group, was provided the opportunity to implement and test their computational algorithms on the MPP. Following one year of work, 28 Working Group members presented scientific papers at the First Symposium on the Frontiers of Massively Parallel Scientific Computation held September 24 to 25 at Goddard. The research endeavors of the MPP investigators span a broad variety of applications including earth science, physical science, signal and image processing, computer science, and graphics. The performance of many of these applications on the MPP was in the supercomputer range to well beyond any existing capabilities. In February, the Working Group presented a report to Dr. Burton I. Edelson, the NASA Associate Administrator for Space Science and Applications, concisely stating their results from using the MPP for one year. FY88 work will center around support of the MPP users. Two more user conferences will be held. The MPP User Support Office will distribute information to users and respond to their requests. Based on their needs, the baseline MPP system software and the library of MPP applications subroutines will be further developed to improve system performance, robustness and ease of use.

W88-70425 **656-31-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SCIENCE APPLICATIONS NETWORKING
Donald L. Gallop 818-354-3842

The objectives of this RTOP are to: (1) assist the EI/Program Manager, Information Systems, to implement the NASA Science Internet Program Plan; (2) determine the networking requirements of the JPL associated science community; (3) ensure that the networks implemented meet the science users needs; (4) assist in designing the architecture of a NASA-wide heterogeneous computer internet based on the Defense Advanced Research Projects Agency (DARPA) TCP/IP protocol suite so that it will provide the science users with intrinsic national and international connectivity; (4) assist in implementing a gateway at JPL that will provide connectivity between JPL networks and the NASA internet and other science nets, such as ARPANET, NSFNET, NOAANET, BITNET, USENET, etc.; and (5) provide on-going support for existing science user networks such as SPAN. The approach will be to plan and implement tasks which will: (1) develop and document the networking requirements of the JPL-associated science community; (2) determine the networking capabilities that need to be implemented at JPL, other NASA supported facilities, or science institutions in order to meet the needs of the JPL science users; (3) support JPL's participation in an architectural design of a NASA-wide coherent logical internet (network of networks) based on the TCP/IP protocol suite which will provide connectivity to major national and international networks (e.g., NSFNET, NOAANET, ARPANET, etc.); (4) coordinate the architectures of the internal JPL TCP/IP based networks, including the Institutional Local Area Network (ILAN), to ensure their logical compatibility with each other and the NASA internet architecture; (5) assist in implementing an IP gateway which will act as JPL's entry point into the NASA internet; (6) provide capabilities, such as routers, that may be required for the continued operation of existing or planned science networks such as SPAN or Earth Science Net; and (7) provide routing center management to the JPL Routing Center for the NASA Science Internet, including the Space Plasma Analysis Network (SPAN) and Earth Science Net.

W88-70426 **656-31-01**
Goddard Space Flight Center, Greenbelt, Md.
COMPUTER NETWORKING
Sol Broder 301-286-7088

The objectives of this RTOP are to: (1) develop and participate in the development of NASA Standard Initiator (NSI), Space Plasma Analysis Network (SPAN), and NSN networks linking computers, workstations, peripherals and data sources inside and outside GSFC; (2) to provide access to the most appropriate computer tools for NASA-sponsored scientists inside and outside GSFC; and (3) to provide leadership, expertise and assistance in developing workstations, interfaces, protocols and other aspects of modern computer networking to meet the needs of the present while investing constructively for the future and avoiding built-in obsolescence. This is a cooperative effort involving the computer users in the Code 600 laboratories, Code 500, other NASA Centers and outside scientists working on NASA projects. A Code 600 network continues to be built using the closed-circuit television (CCTV) cables for communications between the major computers within the Directorate. These are to be linked to Code 500 and to outside users so that they may access the unique facilities of the National Space Sciences Data Center (NSSDC), the Cyber 205, the IBM 3081, and the Massively Parallel Processor (MPP) at high speed.

W88-70427 **656-31-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFORMATION SYSTEMS OFFICE NEWSLETTER
S. Dueck 818-354-0164

The objective of this RTOP is to inform the Space Science and Applications research and science community about Information Systems development and to promote coordination and collaboration between NASA offices and NASA centers by providing a forum for communication on a quarterly basis. The Information Systems Newsletter is produced quarterly and focuses on programs sponsored by the Information Systems Office in support of the Office of Space Science and Applications and includes articles of interest from other office programs and agencies. Collaborative and coordinated Information Systems Office programs are encouraged by developing mechanisms and plans for coordination at specific Information Systems meetings (PCDS, PLDS, PDS, NODS, NAIF, SAR, etc.) and at related workshops, conferences and meetings (PSCN, SAIS, Space Station, etc.). Technical and policy review are provided by JPL's Technology for Space Program Development Office and by NASA Headquarters.

W88-70428 **656-31-05**
Goddard Space Flight Center, Greenbelt, Md.
NASA CLIMATE DATA SYSTEM
Mary G. Reph 301-286-5037

The NASA Climate Data System (NCDS) was first implemented in FY82 as the Pilot Climate Data Base Management System. In FY83, data manipulation utilities and graphics tools were added to the initial catalog, inventory, and data access capabilities, and direct support for scientific researchers began. During FY84, this support was expanded to meet the needs of specific user groups within the Space and Earth Sciences Directorate (formerly the Applications Directorate) of GSFC. In FY85, this support was also provided for several researchers outside of GSFC, including university scientists. During FY86, a transition plan from the pilot system development phase to the operational research support phase was initiated in conjunction with the Earth Science and Applications Division. During 1987, this transition is being completed. During this transition, NCDS has continued to support science users, expanding the direct support of specific universities. During FY88, NCDS will test ideas for improving the system, while continuing support for specific science user groups (in particular, several universities), sharing the operations and maintenance of the computer facility on which the NCDS resides, maintaining system software and data bases, and supporting additional data sets. Included in these improvements are methods to better support increasing needs of the current users and an expanding user community, as well as meet some of the requirements for supporting interdisciplinary Earth science such as is envisioned for the EOS era.

W88-70429 **656-42-01**
Goddard Space Flight Center, Greenbelt, Md.
DISTRIBUTED IMAGE ANALYSIS SYSTEM
Y. C. Lu 301-286-4093
(656-13-50; 656-44-10)

The objective of this RTOP is to develop a portable, comprehensive, distributed image analysis system for use across microcomputer based workstations, minicomputers, and supercomputers to accommodate various levels of computational capabilities. Selected Land Analysis System (LAS) functions will be implemented on a supercomputer. The portability of LAS will be improved by removing VAX/VMS dependencies. The Transportable Applications Executive (TAE) will be used for a standard user-friendly interface to allow access to image processing environment by geographically and scientifically diverse users throughout the multi-disciplinary science community. A software link will be created between microcomputer workstations, minicomputers, and supercomputers. LAS will be downsized so that it may be implemented on a microcomputer. User support will continue through the support office. A transportable distributed LAS image processing system, independent of machines and operating environments and including at least 100 image processing functions and an improved Catalog Manager, will be developed and released to COSMIC. The TAE Display Management Subsystem (DMS) will be modified to operate under both a VAX/VMS environment and a non-VMS environment, UNIX. The TAE Remote Communications Job Management (RCJM) capability will be more extensively used in a heterogeneous machine environment.

W88-70430 **656-43-01**
Goddard Space Flight Center, Greenbelt, Md.
COMPUTER GRAPHICS/VISUALIZATION
Lloyd A. Treinish 301-286-9884

This RTOP includes development of computer based scientific data systems, particularly in computer graphics. Five basic thrusts emerge as being relevant to the ability of a researcher to understand and visualize the complex relationships inherent in any of the multi-dimensional space or earth science data sets that NASA develops with near-term applications, which are: (1) development of correlative visualization and analysis techniques for multiple parameter/dimensional; (2) development of parallel rendering algorithms; (3) establishment of a prototype, portable, operational environment for the visualization of scientific data; (4) distribution of data visualization tools to the scientific community; and (5) utilization of visualization tools on candidate science problems/data sets. In FY88 the strategy is to develop a rapid prototype of an operational, portable system to support correlative data visualization and analysis with limited capabilities using candidate data sets.

W88-70431 **656-43-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COMPUTER GRAPHICS AND SCIENTIFIC VISUALIZATION
R. Holzman 818-397-9697

This visualization of phenomena using computer graphics is proving to be a new, important method for scientists and researchers concerned with planetary study: meteorology, geology, planetary physics, astronomy and astrophysics. This work will emphasize earth science applications and will explore the potential of computer graphics for visualization in earth science problems (hurricanes, atmospheric modeling, ocean circulations, etc.). This RTOP is a four phase effort to: (1) identify current and potential users, (2) consult with the users on existing and needed tools, (3) plan and coordinate the application and demonstration of existing tools, and (4) evaluate prototype tools on a selected basis. In phase 1, potential users interested in earth orbital and planetary studies will be identified. The effort will focus on gaining a broad audience for what the current tools are, the direction new tools are taking, and how they can be applied. Users involved with using instruments on and data from earth orbiting satellites will be emphasized. In phase 2, consultations will be held with potential users to understand their needs for computer graphics for both documentary and research purposes. In particular user problems with current tools and desired capabilities will be identified. In phase 3, plans will be formulated for the application and demonstration of existing tools. Finally, in phase 4, prototype tools will be developed and evaluated in collaboration with investigators to assess how the new tools work as part of the investigation process and how they meet the needs of the users.

W88-70432 **656-44-05**
Goddard Space Flight Center, Greenbelt, Md.
DATA COMPRESSION EXPERIMENTS WITH MULTIDISCIPLINARY DATA
H. K. Ramapriyan 301-286-8744

The objectives of this RTOP are to: (1) investigate techniques for data compression applicable to archival of large volumes of remotely sensed data to reduce costs of media, storage and communications; (2) examine both reversible and irreversible compression; and (3) in the case of irreversible compression, evaluate the fidelity of the compressed and reconstructed data products using remotely sensed data pertaining to several disciplines. The current literature will be reviewed to assess the state of the art in image data compression and prepare a survey paper. Among the techniques to be considered are Huffman coding, run length coding, delta modulation, various transforms (e.g., Cosine, Hadamard), Principal Components transformation, autoregressive models, cluster coding, image segmentation and feature encoding. A candidate set of techniques will be identified for implementation and benchmark tests. The techniques will be tested in consultation with a group of scientists from several disciplines on data sets representative of future high resolution sensors producing large volumes of data. Expected results for FY88 include a survey paper on compression techniques, identification of techniques to be implemented and benchmarked; and testing of two selected techniques on TM, AIS and CZCS data sets.

W88-70433 **656-44-06**
Goddard Space Flight Center, Greenbelt, Md.
GIIAC COMPUTER FACILITY SUPPORT
G. N. Wolford 301-286-7093

The objective of this RTOP is to develop, operate and maintain a computer facility which supports the research of the Information Systems Office (Code EI) as well as other OSSA discipline offices. Fixed-level costs associated with minimum computer system operations support and hardware and software systems maintenance will be obtained by the facility through a number and variety of service contracts. A baseline effective and reliable Image Analysis Facility will be made available.

W88-70434 **656-44-08**
Goddard Space Flight Center, Greenbelt, Md.
GREAT OBSERVATORIES DATA SYSTEM - CATALOGING AND SYSTEM INSTALLATION
Barry E. Jacobs 301-286-5661

The purpose of this project is the development of facilities that will enable astrophysicists to uniformly access data and software. This will be a jointly supported effort between Codes R, N, and E. The methodologies are based on a software system called Distributed Access View Integration Database System (DAVID). Cataloging data and software as well as hardware purchase and maintenance will be supported through the RTOP. The development of DAVID has been and will continue to be supported by Code RC. Interfacing astrophysical data and software to DAVID will be supported through a Code EZ RTOP. Cataloging software and hardware will be provided through the support of Code NTT's Aerospace Research Information Network (ARIN). During this fiscal year we expect to purchase a machine devoted to DAVID. We plan to use it to establish the National Space Science Data Center (NSSDC) as a DAVID astrophysical node on the NSSDC local area network. We also plan to provide wide area access to the node, and catalog the astrophysical data sets that are available at NSSDC on the ARIN system.

W88-70435 **656-44-10**
Goddard Space Flight Center, Greenbelt, Md.
TAE MAINTENANCE AND SUPPORT
Y. C. Lu 301-286-4093

Under this RTOP, enhancements to the Transportable Applications Executive (TAE) will be made to satisfy user requirements and to provide functions that will be needed to support advanced telescience for space station information processing systems. To maintain TAE's system integrity and the currently established high level of reliability, maintenance and configuration control will be done when necessary and/or routinely. The approach will be to continue close contact with the TAE user community and maintain a catalog of potential enhancements. Those features that are of high priority to the user community and fit within the TAE scope and philosophy will be developed for new releases of TAE. User support will continue through the TAE Support Officer (TSO). The TSO has been a highly successful component of TAE development and acceptance. The TSO staff will compile and edit a tri-annual newsletter, coordinate TAE user conferences and workshops, give TAE demonstrations and tutorials, consult on installation and usage of TAE, and develop utility programs to run under TAE. Expected results include development and maintenance of TAE software to support common interface and procedures for use on diverse computing systems and to support advanced telescience applications for space station information processing systems.

W88-70436 **656-44-11**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FLIGHT DATA SYSTEM NAVIGATION ANCILLARY INFORMATION FACILITY
C. H. Acton 818-354-3869
(656-80-01; 155-20-78)

This RTOP will explore hardware and software technologies which will be used to facilitate the use of navigation and related geometric information in the analysis of planetary science data. This work will parallel and support the Planetary Data System (PDS) tasks being funded under RTOP 656-80-01. In FY88 Navigation Ancillary Information Facility (NAIF) activity will focus on evaluating the prototype implementations of the SPICE kernel primary components which were integrated with the PDS in FY87. This will involve extensive interaction with the PDS Discipline Node scientists, and will require work with the PDS User Interface and Data Management teams to refine or augment appropriate components of the PDS central node as well. NAIF will also build prototype portable software tools needed for integrating and subsetting C and E kernels and querying E and I kernels to meet science analysis and PDS catalog query and archiving requirements. NAIF staff will work extensively with PDS Fields and Particles nodes in their experimental use of SPICE kernels and toolkit software for producing observation geometry parameters to be used in their test-bed analysis of Voyager Jupiter bow-shock crossing measurements. NAIF will also test its fully integrated on-line Supplementary Experiment Data Record (SEDR) emulation capability in association with the other Voyager science instruments.

W88-70437 **656-44-11**
Goddard Space Flight Center, Greenbelt, Md.
REMOTE HOST ACCESS TO SUPERCOMPUTERS
G. R. Rumney, II 301-286-4071

The objective of this RTOP is to develop software interfaces to represent remote supercomputer capabilities as though they were local to the user's environment. Workstations are now easily connected to supercomputers via networks, but invariably the workstation interacts with the supercomputer like a dumb terminal or at best with primitive file sending and receiving functions. This RTOP will develop software interfaces spanning the network that will represent remote supercomputer capabilities as though they were local to the workstation environment. Network server software will be developed to make the Massively Parallel Processor (MPP) available transparently from any high level language on any Space Plasma Analysis Network (SPAN) or SESNET DECNET node. All software development, such as editing, compiling and linking, will be done on the user's node, thereby offloading the MPP's host computer. Careful attention will be given to making the design extensible to support supercomputers other than the MPP and network protocols other than DECNET.

W88-70438 **656-45-00**
Goddard Space Flight Center, Greenbelt, Md.
CENTER OF EXCELLENCE FOR SPACE DATA INFORMATION SCIENCES (CESDIS)
Milton Halem 301-286-8835

The objective of this RTOP is to establish and operate at GSFC a Center of Excellence for Space Data and Information Sciences (CESDIS) which will consist of a consortium of university, industry, and government scientists engaged in research addressing NASA's long-term Space and Earth Sciences data and computational problems. This RTOP will support a contract with the Universities Space Research Association to administer, coordinate and manage the award of grants to participating universities, to negotiate appointments of industrial and government associates to CESDIS, to conduct periodic peer reviews of CESDIS by the USRA Council, and to act as the interface between NASA and CESDIS.

W88-70439 **656-45-01**
Goddard Space Flight Center, Greenbelt, Md.
COORDINATED DATA ANALYSIS WORKSHOPS (CDAWS)
Robert E. McGuire 301-286-7794

As understanding in various areas of solar-terrestrial and earth science disciplines matures, the most significant questions that remain tend to be large or global scale. This RTOP will extend the development of organizational techniques and software tools to support the effective and efficient analysis of the data sets needed to address such global problems. The analysis of simultaneous data assembled from many instruments widely dispersed in space and on the ground is essential to the successful resolution of such problems and anticipates requirements of new programs such as the earth observing system (EOS) and International Solar Terrestrial Physics (ISTP). Key elements of the proposed CDAW program include: (1) development of new and enhanced software tools to allow the more effective collection and collaborative analysis of data; (2) continuation of current CDAW activities; and (3) organization of new workshops, with emphasis on extending the range of scientific disciplines to which CDAWs have been applied and on innovative techniques in organizing and assembling the workshops and databases. Specific activities under this RTOP include continuation of the current CDAW-8 research effort, organization of new CDAWs in earth science, astrophysics and solar-terrestrial physics, and technical initiatives to allow quicker and more cost-effective organization and better user access to the accumulated databases.

W88-70440 **656-50-01**
Goddard Space Flight Center, Greenbelt, Md.
NSSDC MASTER DIRECTORY
Joseph H. King 301-286-7355
(656-80-03)

The objective of this RTOP is to continue the development and population of a Master Directory (previously institutionally funded) to the National Space Science Data Center (NSSDC), NASA, and related earth and space science data systems and data sets. Brief, high-level information on the potentially useful data systems and data sets will be entered in the directory and links to the data systems or catalogs containing further information about the data will be established where this can be done easily. By the end of the first fiscal year the directory will be advertised as the first place to look and a useful tool in rapidly locating data in the earth and space sciences. The currently operating NSSDC Central Online Data Directory (CODD) will be split into a directory level containing brief information about data systems and data sets; modified to agree with the format determined in the Catalog Interoperability Working Group (see related RTOP 656-80-03), and a catalog level containing more detailed information about data

sets if such information is not already stored in other data systems or catalogs. By use of the interactive input system, electronic mail, the automated input system, or other means as necessary, the directory level will be populated and kept as up to date as possible with information about data systems and data sets of potential use to the scientific community with emphasis on those which are NASA-funded. The information will be reviewed as it is entered and then placed in the permanent database. Where it is agreeable and easily accomplished, connections from the directory to the useful data systems will be established. Technical approaches for improving directory updating and overall performance will be assessed.

W88-70441 **656-50-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OSSA CODE EI DETAILEE
P. M. Zion 818-354-8730

The objective of this RTOP is to provide support to the Information Systems Office of the Office of Space Science Applications (OSSA) by the assignment of a JPL detailee to NASA Headquarters. The primary duties of the detailee will be to provide assistance in the development and monitoring of the NASA Information Systems programs.

W88-70442 **656-50-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EARTH SCIENCE APPLICATIONS DATA SYSTEMS (ESADS) SUPPORT: INTEROPERATIONS, DATA STANDARDS, AND IMPLEMENTATION COORDINATION
James W. Brown 818-354-3614
(656-80-03)

The objective of the ESADS combined RTOP is to address some of the priority issues identified by the ESADS committee. This is the first year of a three-year effort which is intended to facilitate the implementation of ESADS objectives within the existing data systems at JPL. Tasks under this RTOP are chosen to complement the existing work going on within the data systems, and to emphasize those areas which have been identified as ESADS priorities, but which may not otherwise have been included in the individual data systems plans. This RTOP addresses three items identified in the original RTOP call: (1) catalog interoperability, (2) standards for earth science data, and (3) ESADS implementation coordination. The catalog interoperability task focuses on identifying the agreements, interfaces, and implementation efforts required to enable the various data system catalogs to exchange information, and evolve toward a true distributed information system. The standards task will seek agreement on detailed format standards for specific earth science data sets of high current interest, such as the Advanced Very High Resolution Radiometer (AVHRR) and the Coastal Zone Color Scanner (CZCS), and will demonstrate standard formatted data unit (SFDU) performance for the Airborne Visible and Infrared Spectrometer (AVIRIS) data set. The ESADS implementation coordination will address some remaining priority implementation efforts identified in the context of the JPL data systems, and will provide for the overall management and technical coordination of the ESADS implementation efforts at JPL. Since these efforts are closely related, they have been combined in order to ensure the maximum coordination and focus.

W88-70443 **656-55-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EOS ADVANCED DATA SYSTEMS DEVELOPMENT
David A. Nichols 818-354-8912
(656-11-05)

Successful development of the earth observing system (EOS) Data and Information System (EOSDIS) faces a significant challenge in meeting the needs of the high rate Synthetic Aperture Radar (SAR) and High Resolution Imaging Spectrometer (HIRIS) instruments. Each instrument is a major step forward in capability from the current instruments. Data and information system concepts and implementations for support of these instruments cannot be met by simple extension of any existing operational system. One of the most significant challenges is building affordable ground elements which can support the extreme data volumes and rates in an environment responsive to science needs. When faced with such a significant advance in system capability, the typical approach of system requirements, design, implementation and operation in a single linear stream carries very high risk. To meet the needs of the high rate instruments in the EOSDIS, an iterative approach is needed in which requirements and design identify functions which represent a significant risk or technology challenge, prototype construction of system elements solves the technology challenge, and the requirements and design are then re-evaluated based on the results of operating prototype elements in a testbed system which realistically represents the data system operational environment. This task would continue the process begun in FY87 of creating an overall design and a development plan for support of the high rate instruments in the EOS Data and Information System along with the implementation of selected components of an Instrument Control Center leading to a demonstration of remote instrument commanding during the SIR-C (Spaceborne Imaging Radar) mission.

W88-70444 **656-55-10**
Goddard Space Flight Center, Greenbelt, Md.
EOS DATA AND INFORMATION SYSTEM
Albert J. Fleig 301-286-7747

Science requirements for the Earth Observing System's Data and Information System, EOSDIS, are a radical departure from those for previous flight programs. EOS is to provide an overall system for acquisition, processing, archival, cataloging, retrieval, and analysis of all earth observations required for multidisciplinary research that forms the fundamental basis for the program. No previous Earth Science data system has such a broad goal and there is no NASA precedent for the design and implementation of the EOSDIS. However, the EOS Program must understand the issues involved within the next 18 calendar months to provide the information required by NASA as part of the new start authorization process. Preparation of an adequate program plan requires identification of requirements, development of concepts, and preparation of resource estimates for the entire EOSDIS. Major areas that pace the EOSDIS in terms of schedule, technology, and resources have been identified and are the subjects of the first ten tasks under this RTOP. The next three tasks provide overall systems engineering and coordination for the above effort, document scientific requirements and resulting inferred design requirements, and establish the basic environment and standards for the entire Program. The final effort covers those tasks identified to the Earth Sciences Applications Data System (ESADS) as both high priority and appropriate for EOS Project activity. The EOS Project will provide an ESADS Ombudsman and will coordinate and integrate ESADS identified activities which are directly related to EOS Project requirements. We will participate in the test of data ingest schemes. Support to broaden the catalog interoperability effort to include other government agencies and developers of other discipline data systems will be provided by sponsoring workshops and other activities as identified by the ESADS panel. Similar support will be provided in the area of standard formatted data units (SFDU's) and common data formats (CDF's).

W88-70445 **656-62-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SYNTHETIC APERTURE DATA SYSTEM
J. Curlander 818-354-8262
(656-80-01; 656-11-01; 656-13-50; 656-13-40)

Microwave remote sensing of earth and planetary surfaces is currently receiving a substantial amount of development in both the U.S. and abroad. NASA Synthetic Aperture Radar (SAR) flights in the implementation and planning stages include: the new aircraft SAR development, the Shuttle Imaging Radar (SIR) series, the Magellan system and the EOS SAR planned for the mid-1990's. Currently, the existing digital SAR data handling facilities cannot adequately meet anticipated needs to produce high quality products in a timely fashion. This not only compromises science

investigations but also increases the cost of data processing operations. Besides the SAR image formation processing systems, a number of issues in the end-to-end data system need to be investigated to facilitate future mission design and implementation. The two primary issues are image quality and data system design trade-offs; and formulation and implementation of multimission standards (i.e., data formatting, interfacing and distribution). An optimal resolution of these issues will greatly enhance the cost-effectiveness of the overall SAR system for science applications and provide a sound basis for development of a true multi-mission data network. The overall objective of this RTOP is to develop, evaluate, and demonstrate end-to-end data system concepts and data processing techniques to facilitate and automate transmission, processing and analysis of data gathered by future spaceborne and airborne SAR sensors. The primary emphasis is data system development for OSSA SAR missions with consideration of other U.S. and international remote sensors currently in development or planning stages. The general approach to the development of data system elements for SAR missions is phased as follows: (1) conduct end-to-end data system development planning; (2) identify needed subsystem elements that require new research and development; (3) integrate subsystems and conduct system operations experiments; and (4) upgrade existing system to meet new requirements.

W88-70446 **656-62-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIRIS DATA PROCESSOR
J. E. Solomon 818-354-2722

The objective of this task is the implementation of hardware and software technologies required for support of the Earth Observing System (EOS) High Resolution Imaging Spectrometer (HIRIS) instrument system with respect to ground data processing operations and interfaces required with the EOS Data System. A major objective of this work is the implementation of a HIRIS Concurrent Processor testbed within which to evaluate both algorithmic and systems issues associated with HIRIS Level 0 through Level 3 processing requirements. Secondary objectives of this work are evaluation of the utility of high performance concurrent processing workstations for science information extraction, and utilization of the testbed facility for processing of other imaging spectrometer instrument data. The results of this work will be compiled into a detailed design specification document for the HIRIS ground data processor. The approach to be taken in this work consists of the following elements: (1) implementation of a combined multiple instruction multiple data and single instruction multiple data (MIMD/SIMD) concurrent processing testbed environment; (2) derivation of Level 0-3 processing of HIRIS data stream using Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) data sets; (3) algorithm design and validation for HIRIS Level 0-3 operations in MIMD/SIMD architectures; and (4) utilization of results to derive HIRIS Ground Data Processor design specifications.

W88-70447 **656-80-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY DATA SYSTEM
J. T. Renfrow 818-354-6347
(155-20-70; 656-11-01; 656-13-40; 656-13-50; 656-44-11)

The overall objective of this RTOP is to conduct evaluations of methodologies, standards, and technologies which can be used in solving the data problem of the planetary science community and to do these evaluations with Science Testbeds which are run by working planetary scientists. The detailed objectives of this RTOP are to: (1) develop system concepts and evaluate these concepts and also appropriate technologies to support the archiving and accessing of planetary science data by the planetary science community; (2) have the actual users of the technologies try out and evaluate at their home institution the technologies being studied; and (3) develop and demonstrate the efficacy of data administration, data format, and data nomenclature standards for use across the full spectrum of future planetary missions and data restoration activities. To meet these objectives a three fold approach will be used. System components and applicable technologies will be developed to test and validate functional and performance requirements and serve as testbeds for technology. These system and technological components will be developed in such a way that the ability to incorporate these components into the operational Planetary Data System (PDS) is maximized. Scientists involved in the project will actually use the testbeds to perform science functions. Data standards will be developed, validated, and demonstrated in the development of optical disks and planetary science data catalogs and data bases.

W88-70448 **656-80-01**
Goddard Space Flight Center, Greenbelt, Md.
ASTRONOMICAL DATA PROCESSING WITH DESK-TOP COMPUTERS
Sara R. Heap 301-286-5359

We propose to build a turn-key system for desk-top computers that can process images and spectra of SN 1987A and other astronomical objects, as obtained by NASA satellites or from ground-based observatories. This system will allow astronomers to acquire, process, analyze and interpret imagery and spectral data at their home institutions. Our strategy will be to utilize recently developed computer hardware and operating systems and to convert existing applications software previously developed for VAX-VMS systems to desk-top computers. (The bulk of the existing software is written in Interactive Data Language, VAX-IDL, which is presently being re-written in C, so as to become effectively machine-independent.) Progress in desk-type computers that make the proposed work feasible includes: (1) high-capacity data-storage devices for desk-top computers; (2) local and international networks; (3) 80386-based CPUs and operating systems featuring large memories, virtual addressing, and high computing speeds; and (4) the conversion of VAX-IDL to C-based IDL (in progress), which will make the move from VAX computers to desk-top computers relatively easy. Proposed FY88 accomplishments include analysis of hardware and operating systems (e.g., Unix 5 vs. OS/2); purchase of computer hardware and operating system; and design of turn-key system. FY89 will see purchase of C-based IDL and conversion of software for processing images (including image deconvolution) and first-order spatially resolved spectra. Conversion of software for processing echelle (2-D) spectra is anticipated for FY90.

W88-70449 **656-80-01**
Goddard Space Flight Center, Greenbelt, Md.
ASTROPHYSICAL/SUPERNOVA SUPPORT
Milton Halem 301-286-8834

The goal of this RTOP is to support the scientific objectives of the astrophysical community, especially for analysis of supernova data through the use of the Interactive Data Reduction and Analysis Facility (IRAF) and the Astronomical Image Processing System (AIPS) astrophysical image processing software systems available at the Goddard Image Analysis Facility. Space Plasma Analysis Network (SPAN) communications capability will be supplied to access major observatories participating in the supernova research activities. Telemail and Telenet access will be provided for supernova researchers in the U.S., Canada, Chile, and Australia by providing documentation, software, logistical support, and system resources as needed. Additional objectives include: (1) providing access to the Strasbourg astronomical data bank (SIMAD) for obtaining bibliographical references and observational data concerning Supernova 1987A as well as information about other supernovas, related stars and galaxies; (2) providing support for detailed restoration of astrophysical images requiring extensive deblurring and enhancements techniques; and (3) conducting an NSSDC Coordinated Data Analysis Workshop (CDAW) centered on observations of Supernova 1987A. There are three broad areas of resource support that will be made available to scientific researchers engaged in the analysis and understanding of this unique physical phenomenon. This support will entail providing access to specialized astrophysical computational system and data archives, science user support through installation of communication networks and supporting coordination workshops.

W88-70450 **656-80-03**
Goddard Space Flight Center, Greenbelt, Md.
INTEROPERABLE CATALOGS
James R. Thieman 301-286-9790
(656-50-01)

The objective of this RTOP is to investigate, define, and implement a standardized approach to interconnecting the National Space Science Data Center (NSSDC) Master Directory and selected NASA-supported discipline data systems (principally, NASA Ocean Data System (NODS), Pilot Climate Data System (PCDS), Pilot Land Data System (PLDS), NSSDC Information Management System (NIMS), and Planetary Data System (PDS) at the present time) in order to develop and demonstrate interoperability among data systems for rapid and versatile data information retrieval and automated update capability. In an effort coordinated by the NSSDC, representatives from each of the data systems would work together to complete several steps: (1) determine together with scientist/users, requirements for interoperability; (2) develop and implement a simple connection scheme in which the user learns from a directory of the existence of a discipline data system for data sets of interest and can choose to be transferred to it through computer networks; (3) use a common directory interchange format for passing information to and from the directory and data systems for assisting a user in searches among the systems and for automated input and updating of information in the directory; and (4) define and implement, where possible, capabilities for automated multi-system searching. As a by-product of the completion of these steps a set of guidelines or standards on data system terminology, structure, user interface, etc., will be developed as recommendations for the design of future discipline and project data systems.

Climate Research

W88-70451 **672-20-00**
Goddard Space Flight Center, Greenbelt, Md.
CLIMATE PROCESSES
Otto W. Thiele 301-286-9006
(672-10-00; 672-30-00; 672-40-00; 672-50-00)

The objective of this RTOP is to extract information on climate and climate related parameters from satellite data, and develop techniques for remote sensing of climate parameters, including the development of methods for extracting cloud cover parameters from existing satellite images in support of the International Satellite Cloud Climatology Project (ISCCP) and the First ISCCP Regional Experiment (FIRE). We will participate in field experiments such as FIRE, conduct theoretical studies to develop methods for remote sensing of cloud parameters, and collect aircraft remote sensing data on a variety of cloud types to achieve a better understanding of the radiative properties of clouds. Algorithms will be developed for determining cloud cover amount, cloud height, cloud absorption within clouds, and cloud type from multichannel satellite images. We will utilize microwave data from Nimbus 7 Scanning Multichannel Microwave Radiometer (SMMR) to produce maps of sea surface temperature, atmospheric water vapor, atmospheric liquid water, and surface winds; conduct analyses of the data to determine their validity; explore potential use of the data to estimate energy and moisture exchange between the oceans and the atmosphere; and analyze Ocean Temperature Scanner (OTS) data collected during MASEX. We will examine the potential use of satellite altimetry data (Seasat and GEOS-3) to study changes in the ice sheets that may affect climate.

W88-70452 **672-21-02**
Ames Research Center, Moffett Field, Calif.
AEROSOL AND GAS MEASUREMENTS ADDRESSING AEROSOL CLIMATIC EFFECTS
R. F. Pueschel 415-694-5254

Goals of this program are to advance the understanding of aerosol effects on climate, and to focus especially on the effects of major volcanic eruptions and major tropospheric hazes such as the Arctic haze. The approach involves collecting, analyzing, interpreting and publishing data on the aerosol particles and precursor gases that constitute or form the hazes of interest. The U-2, ER-2, C-130 and the DC-8 are used as platforms to access the subject aerosols. The physical and chemical properties of the aerosol particles are determined in situ with commercial and in-house-developed sensors. Optical properties of the hazes are derived from these measurements invoking light extinction theory.

W88-70453 **672-22-06**
Goddard Inst. for Space Studies, New York, N.Y.
EXPERIMENTAL CLOUD ANALYSIS TECHNIQUES
William B. Rossow 212-678-5567

The objective of this RTOP is to test cloud analysis algorithms, particularly that used by the International Satellite Cloud Climatology Project (ISCCP) as its operational algorithm, for cases which present difficult problems such as the polar regions, and develop new cloud algorithms. The approach will be to: (1) test ISCCP results in polar regions against other satellite cloud algorithms and multi-spectral radiative analysis of Advanced Very High Resolution Radiometer (AVHRR) data; (2) test ISCCP results by radiative model comparisons to First ISCCP Regional Experiment (FIRE) observations of cirrus and marine boundary layer clouds; and (3) develop methodologies to infer cloud-radiative feedbacks from ISCCP data. Expected results include improved understanding of utility of current and planned satellite observations for determining polar region cloudiness and inference of cloud-radiative feedback from ISCCP cloud climatology.

W88-70454 **672-22-13**
Ames Research Center, Moffett Field, Calif.
FIRE-CLOUD RADIATION RESEARCH
F. P. J. Valero 415-694-5510

The interaction of radiation with clouds plays a fundamental role in the earth's energy budget. The objective of this work is to study the measurement and modeling of the interaction of radiation and clouds including radiative flux divergence profiles, optical depths, total/diffuse radiation field and particle size distributions in stratus and cirrus clouds. It is a fundamental objective of this work to validate satellite-acquired radiative data. Measurement will be made using aircraft as instrument platforms during the First International Satellite Cloud Climatology Regional Experiment (FIRE) deployments. From the above measurements, the significant radiative energy parameters are determined and used in radiative transfer modeling to validate model prediction.

W88-70455 **672-31-00**
Goddard Space Flight Center, Greenbelt, Md.
CLIMATE MODELING AND ANALYSIS
Yogesh Sud 301-286-7408
(672-10-00; 672-20-00; 672-40-00; 672-50-00)

The objectives of this RTOP are to develop climate modeling capabilities, to guide the design of the observing system, to optimize analysis techniques for the utilization of space-acquired data, to carry out studies of physical processes important to climate, and to assess climate predictability. We will develop semi-empirical methods for understanding, detecting, and predicting climate change. The Goddard Laboratory for Atmospheres (GLA) General Circulation Model (GCM) will be improved for use in seasonal cycle predictability studies. We will develop efficient radiative transfer routines for use in climate models and conduct studies of the sensitivity of climate to radiative forcing using the seasonal version of the GLA multi-layer energy balance model (MLEBM). Planetary boundary layer (PBL) parameterization methods will be developed for global models. We will study blocking events to identify dynamical predictors and conduct extended range climate forecast and predictability experiments. The 15-year natural variability run and a six-year predictability run with a state-of-the-art GCM will be continued. The parameterization for fractional cloudiness installed in the GLA/UCLA model and the high resolution version of that model will be tested. The optimal weighting method for detection of climate change for its stability to sampling errors will be examined. We will develop statistical methods to make

better use of existing data for determining such climate parameters, rainfall and clouds. The IR radiation routine will be vectorized and inserted into the GLAS GCM. The sensitivity of climate to transient CO2 will be studied with the seasonal version of the MLEBM.

W88-70456 **672-31-02**
Ames Research Center, Moffett Field, Calif.
AEROSOL FORMATION MODELS
O. B. Toon 415-694-5971
(672-32-99)

The objectives of the work are to simulate the ambient stratospheric aerosol layer and the El Chichon volcanic cloud, to extend the knowledge gained by studying the El Chichon cloud to larger eruptions and to begin to play a role in NASA studies of water clouds and their effects on the radiation balance. The volcanic cloud and ambient simulations will be compared with observations, and will be used to create input data sets for climate models, to test data sets for internal consistency and to determine better the physics and chemistry of the stratosphere. The model offers the best means of extrapolating the knowledge gained from the El Chichon eruption to other eruptions of greater or lesser magnitude. A three-dimensional tracer transport model has been developed. A radiation code has been developed to drive a stratospheric dynamics model that will be used to investigate radiative interactions between the volcanic cloud and stratospheric winds. Also a model of tropospheric cloud condensation nuclei physics and chemistry has been developed for use in exploring cloud formation processes and their impact on cloud radiative properties.

W88-70457 **672-31-03**
Goddard Inst. for Space Studies, New York, N.Y.
GLOBAL CLIMATE MODELING
James Hansen 212-678-5619

The objective of this RTOP is to develop and apply climate models to support NASA's Climate program, particularly carrying out basic research which helps define observing systems requirements for monitoring, analysis and prediction of long-range climate change. Climate modeling capability appropriate for analysis of long-range climate will be developed. Principle areas of model development are in the areas of clouds, radiation, convection and numerical methods. The approach involves testing more realistic or accurate representations of these physical processes or numerical schemes, using the previously developed Model 2 as a control for these experiments. The current Model 2 will be used for climate studies aimed at obtaining a better understanding of global climate sensitivity and projections of transient climate change during the next 10 to 50 years. This includes experiments in which the global greenhouse forcing changes at a realistic rate on decadal time scales.

W88-70458 **672-31-12**
Goddard Inst. for Space Studies, New York, N.Y.
HYDROLOGIC PARAMETER GISS GCM
Anthony D. Del Genio 212-678-5588

The overall objective of this work is to test and improve the capability of the Goddard Institute for Space Studies (GISS) general circulation model (GCM) to reproduce critical aspects of global hydroclimatology, via the development of new diagnostic methods for evaluating the cycling of moisture in the model and the implementation of subgrid-scale fluctuations in the model's ground hydrology parameterization. Principal elements of the approach are: (1) development of a tracer model version of the GCM which can follow the trajectories of atmospheric water vapor molecules from source to sink locations; (2) comparison of model simulated precipitation depth, duration, and storm intervals to observations at selected locations; and formulation and testing of the effects of subgrid-scale soil moisture variations in the GCM ground hydrology parameterization based on observed precipitation probability density functions and field studies of storm catchment areas.

W88-70459 **672-32-01**
Ames Research Center, Moffett Field, Calif.
CLIMATE MODELING ASSESSMENT
T. P. Ackerman 415-694-5233
(672-31-99; 672-22-99)

A coordinated set of theoretical, laboratory, and field investigations of the chemical and radiative properties of clouds and natural (e.g., volcanic) and man-made atmospheric aerosol particles are conducted in order to assess their impact on regional and global climate. The field investigations are intended to provide complementary information on clouds and aerosols to that being obtained from spacecraft platforms (e.g., SAM, SAGE II and SME) so as to insure that a comprehensive set of properties is gathered for climatic analyses. The theoretical and laboratory tasks are directed at interpreting and utilizing the data sets to perform the desired climatic assessments. The centerpiece of the field investigations is a set of coordinated experiments which are flown together on appropriate aircraft platforms. Both theoretical modeling and laboratory studies are used to define the mechanisms of aerosol and cloud formation to provide hypotheses that can be tested by the field investigations and to ultimately provide predictive tools. Theoretical investigations involving radiative transfer, dynamics, and formation are utilized for making the climatic assessments.

W88-70460 **672-50-01**
Ames Research Center, Moffett Field, Calif.
AMES MULTI-PROGRAM SUPPORT FOR CLIMATE RESEARCH
T. P. Ackerman 415-694-5233
(672-21-99; 672-31-99; 672-32-99)

The objective is to consolidate Ames Multi-Program Support (MPS) costs for the Ames 672- program so that charges need not be made against individual RTOPs in the UPN. The 672-program supports the study of cloud-climate interactions through observational and theoretical tasks. These include aircraft measurements of solar and infrared fluxes in cloudy atmospheres; synthesis of the flux measurements with other aircraft and satellite observations; radiative transfer modeling of cloud interactions; theoretical studies of cloud condensation nuclei (CCN) formation and cloud growth; and measurements of CCN concentrations and properties.

W88-70461 **672-50-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CLIMATE PROGRAM SUPPORT
R. K. Kakar 818-354-7748

The objective of this RTOP is to provide support to the NASA Atmospheric Dynamics and Research Branch, Earth Science and Applications Division, by providing the services of a JPL detailee to NASA Headquarters.

W88-70462 **672-80-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AIRBORNE RAIN MAPPING RADAR SYSTEM
F. Li 818-354-2849

The objective of this task is to develop an airborne rain mapping radar (ARMAR) to demonstrate accurate remote precipitation measurements. ARMAR will be used to verify the technique, technology and data processing algorithms for future satellite rain measurement missions, such as the planned Tropical Rain Mapping Mission (TRMM). In FY87, a preliminary design of ARMAR was completed and the design will be reviewed in September '87. The design consists of a 14/35 GHz radar with a narrow scanning antenna beam. Pulse compression will be used to improve signal-to-noise ratio and increase the number of independent samples. It will be flown on the NASA Ames DC-8. In FY88, we will refine the design of the subsystems and will issue procurements of appropriate long lead-time items. The goal is to complete the 14 GHz channel by FY90 and the full system by FY91. In FY88, we will develop detailed interfaces with the DC-8 as well as generate internal interface documents. At present, we are still awaiting NASA Headquarters direction on the possibility

of accelerating the implementation schedule to two years and whether an electronically scanned antenna will be used. If either of these options are adopted, a revised implementation plan will be submitted.

W88-70463 **672-90-20**
Goddard Inst. for Space Studies, New York, N.Y.
GLOBAL HABITABILITY STUDIES
James Hansen 212-678-5619

This is pass through support for the Columbia University Seminar on Global Habitability organized by the Provost's Office. The objective is to define and illuminate the scientific and social issues relating to the environment of our planet and man's impact upon it. The approach will be to define, with the help of scientists at Goddard and NASA Headquarters, appropriate topics and speakers. Emphasis is on topics of broad interest relevant to global satellite observations, particularly to the emerging NASA contributions to the International Global Change program.

Stratospheric Air Quality

W88-70464 **673-00-00**
Langley Research Center, Hampton, Va.
STRATOSPHERIC AIR QUALITY
William L. Grose 804-865-4788

The objective of this RTOP is the application of remote sensing technology and measurements for environmental monitoring of the stratosphere. Data analysis techniques and theoretical model studies will be used to improve our understanding of the stratosphere and potential changes to its composition and structure. Specific tasks include: (1) develop empirical models of a variety of existing sets of stratospheric data, and studying the systematic variations of constituents; (2) study photochemical and dynamical processes in the stratosphere using Nimbus 7 Limb Infrared Monitor of the Stratosphere (LIMS) data in conjunction with existing theoretical models; (3) develop and evaluate orbital analyses, instrument modeling, and sampling simulations to define mission concepts for advanced satellite experiments; (4) establish a pilot electronic data base consisting of stratospheric trace gas data from both measurements and models to facilitate rapid dissemination of data to the scientific community; (5) study the distribution and variation of odd nitrogen in the stratosphere using satellite data sets in conjunction with radiative and photochemical models; and (6) investigate stratospheric dynamics and transport processes using a 3-D circulation/transport model and global sets of satellite data.

W88-70465 **673-41-12**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STRATOSPHERIC CIRCULATION FROM REMOTELY SENSED TEMPERATURES
L. S. Elson 818-354-4223

The objective of the research is to develop an improved quantitative understanding of the large scale circulation of the lower stratosphere in the 15 to 30 km region. Included in the topics addressed are both free and forced waves along with the zonally averaged component of the circulation. A major theme of the investigation is to examine traditional scaling approximations which have been applied to the stratosphere. Such approximations have been based mainly on tropospheric applications and are not always appropriate for stratospheric problems. When an approximation is found to be inappropriate, an alternative approach is developed. The technique employed maximizes the use of high quality satellite data which provides both global coverage and good vertical resolution. For these applications, limb observations (Nimbus 7 LIMS) have been found to be superior to other data sets. By inferring the circulation from the observations, the results are less dependent on modeling assumptions. The use of data also allows the selection of dominant processes from among competing theoretical models.

W88-70466 **673-41-51**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SME OZONE AND MST RADAR
M. Allen 818-354-3665

Solar Mesosphere Explorer (SME) ozone and solar flux measurements along with quasi-simultaneous ground-based microwave water vapor measurements will be used to study the photochemistry of the mesosphere. Comparison will be made with results of up-to-date photochemical models to test the adequacy of the current picture of the upper atmosphere.

W88-70467 **673-41-62**
Goddard Space Flight Center, Greenbelt, Md.
TEMPERATURE TRENDS
R. D. Hudson 301-286-5485

The objectives of this RTOP are: (1) to enhance our understanding of the behavior of stratospheric composition over time scales of the 27-day solar rotation period, the annual cycle, and the 11-year solar cycle and to delineate the driving mechanisms of these variations; (2) to develop models of the variability in the ultraviolet solar irradiance which can be used to predict atmospheric responses for comparison with measurements; and (3) to analyze aspects of radiation transfer related to the penetration of biologically relevant solar wavelengths to the earth's surface. Data obtained by satellite-based remote sensors will be analyzed using models of latitudinal, zonal, and temporal variability and theoretical models of radiation transfer and photochemical production, loss, and transport. Long term climatological data sets will be assembled for the study of annual and interannual variations and their driving mechanisms, plus responses to solar activity. A long term ultraviolet solar irradiance data base will be collected and analyzed to better define possible mechanisms of solar variability.

W88-70468 **673-42-01**
Ames Research Center, Moffett Field, Calif.
ANALYSIS OF TROPOSPHERE-STRATOSPHERE EXCHANGE
L. Pfister 415-694-5491

The overall goal of this work is to improve our understanding of the role of small scale motions in stratosphere-troposphere exchange in the tropics. Specifically, analysis will be made of aircraft, radiosonde, and satellite data from the 1980 NASA field experiment in Panama and the 1987 NASA field experiment in Australia to: (1) examine the structure of ozone, temperature, and water vapor within, around, and above cumulus anvils; (2) establish the presence, during the experimental period, of various potential mechanisms of exchange, such as direct injection by cumulus, gravity wave fluxes, and turbulent fluxes; and (3) evaluate quantitatively, if possible, the mass of air transferred by these mechanisms during specific transport events.

W88-70469 **673-61-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MESOSPHERIC THEORY
R. W. Zurek 818-354-3725

The goal of this task is to better understand the interaction of photochemistry and mass transport in the terrestrial upper atmosphere. The approach is to develop in collaboration with Y. Yung (Caltech) and M. Allen (JPL/CIT) a 2-D interactive model containing coupled chemistry and transport relevant to the stratosphere and mesosphere. This model would then be used to simulate and interpret the observed distributions of photochemically important atmospheric trace constituents observed from airborne and spaceborne platforms.

W88-70470 **673-61-03**
Ames Research Center, Moffett Field, Calif.
STRATOSPHERIC DYNAMICS AND PARTICULATES
R. E. Young 415-694-5521
(672-31-99)

The objectives of this research are to increase our understanding of the dynamics, thermodynamics, and composition of the earth's stratosphere, and to investigate the mechanisms by which trace species are exchanged between troposphere and

stratosphere. The research will involve a combination of theoretical and observational studies. Global and mesoscale circulation models will be used to investigate transport and exchange processes. Satellite data analysis will be used to characterize wave and transport phenomena in the stratosphere. Meteorological and diagnostic analysis will be conducted in support of aircraft measurement programs, such as the Troposphere-Stratosphere Exchange experiment. The studies in particulates are to construct models of stratospheric aerosols and to compare simulation with observations in order to learn more about stratospheric dynamics and chemistry and to construct numerical models of polar stratospheric clouds and compare simulations with observations in order to learn more about processes occurring in the Antarctic Ozone Hole.

W88-70471 **673-61-07**
Goddard Inst. for Space Studies, New York, N.Y.
CLIMATOLOGICAL STRATOSPHERIC MODELING
David Rind 212-678-5593

This RTOP has as its objectives: (1) contributions toward understanding the impact of potential climate perturbations on the stratosphere; (2) assessment of the effect of any alterations in stratospheric dynamics on the impact of anthropogenic releases on stratospheric ozone; and (3) better understanding of the expected changes to be observed in the next several decades. Three-dimensional modeling of the troposphere stratosphere mesosphere system will take place to delineate climate change influence on the stratosphere. Results will be saved for use with photochemical models. Expected results include an estimate of the effects of climate perturbations for the next several decades as well as further into the future on ozone sensitivity to anthropogenic perturbations.

W88-70472 **673-62-08**
Goddard Space Flight Center, Greenbelt, Md.
UPPER ATMOSPHERE RESEARCH: THEORETICAL STUDIES
P. D. Guthrie 301-286-5830

The objectives of this RTOP are to: (1) provide the framework for developing and understanding an organized, solid body of knowledge of the physics, chemistry, and dynamics of the earth's upper atmosphere; (2) analyze data from upper atmospheric flight programs; and (3) predict and assess the effects of natural and man-related perturbations on the atmosphere. We will continue to develop and utilize a hierarchy of models of upper atmospheric photochemistry and radiation ranging from simplified models to the incorporation of chemistry into a global general circulation model. Field measurement data will be utilized to elucidate the controlling mechanisms for atmospheric composition and variations. Expected results include improved photochemical models and improved understanding of the coupling between chemistry and transport.

W88-70473 **673-63-00**
Goddard Space Flight Center, Greenbelt, Md.
SUNRISE/SUNSET EFFECTS
J. R. Herman 301-286-7821

The objectives of this research are to develop the capability to obtain air parcel trajectories in the stratosphere from satellite temperature measurements and to compute the composition of the stratosphere including the interaction between chemistry and dynamics. The approach is to extend the existing Lagrangian parcel model to include local heating effects so that parcel motions are no longer constrained to isentropic surfaces, and to account for the finite lifetime of individual parcels. The latter is a major problem of redistributing a parcel's contents among its neighbors when wind shear has stretched or distorted a parcel so that its contents cannot be reasonably associated with a geographical location. Numerical experiments show that parcel lifetimes range from hours (where air streams meet) to from 4 to 10 days in quiet flow conditions. The model is to be applied to cases where dynamics is likely to play a significant role in determining the stratospheric composition. Common examples would be the south polar ozone hole and the large structure in ozone observed in the lower stratosphere at all latitudes.

W88-70474 **673-64-00**
Goddard Space Flight Center, Greenbelt, Md.
GENERAL CIRCULATION AND CHEMISTRY
Marvin A. Geller 301-286-5002
(673-41-00)

The objectives of this RTOP are to provide a framework to understand the natural stratosphere and its response to external perturbations and to enhance our understanding of the two-way interactions between troposphere and stratosphere. The approach will be to develop computer models of the troposphere-stratosphere system and compare results to observations. Expected results include improved understanding of the stratospheric radiative chemical dynamic system.

W88-70475 **673-64-04**
Goddard Inst. for Space Studies, New York, N.Y.
STRATOSPHERIC CHEMISTRY IN A GCM
Michael Prather 212-678-5625

The proposed research emphasizes the 3-D transport of chemically active species in the stratosphere. Work will center on the development of the 21-layer chemical transport model for the stratosphere. Task 1, 21-layer tracer model, involves development and validation of a stratospheric chemical tracer model based on experience with similar tropospheric models. The chemical model will be limited to photolytic destruction of species such as chlorofluorocarbons (CFCs) and N2O. Comparison will be made with observations. Task 2, Stratospheric Chemistry, involves parameterization of a complete ozone chemistry for use in the stratospheric tracer model. Task 3, Perturbated Atmospheres, involves relying on the 21-layer general circulation models (GCM) simulation of CO2 and O3 perturbations to the stratospheric circulation, using chemicals to assess the impact on lifetimes of long-lived tracers and on ozone.

Space Processing Science and Spacelab Payload Development

W88-70476 **674-21-06**
Langley Research Center, Hampton, Va.
ELECTRONIC MATERIALS, VAPOR GROWTH AND LOW-G GRAVITY TECHNIQUES
A. L. Fripp 804-865-3777
(694-80-70)

The objective of this research is to gain a better understanding of the role of fluid dynamics in the growth of crystals by vapor transport. Both a theoretical and an experimental investigation will be conducted. Model materials may be used to simulate actual crystal growth systems. This work is of a fundamental nature and will support the science base needed to design space flight experiments.

W88-70477 **674-23-01**
Lyndon B. Johnson Space Center, Houston, Tex.
BIOTECHNOLOGY RESEARCH
Dennis R. Morrison 713-483-7123

This research is devoted to screening of new candidates, formulation of new biological separation flight experiment proposals, and developing appropriate ground control experiments. These projects are designed with five objectives: (1) to gain a better understanding of basic science questions uncovered by microgravity separations of cells and cell secretory products purified directly from various culture media; (2) to define and screen new candidate cells or cell products for possible electrophoretic separations or cell culture experiments using the Continuous Flow Electrophoresis System (CFES) or the Cell Culture Bioreactor; (3) study unique bioprocess limitations caused by gravity dependent phenomena and determine the improvements expected during

biological processing in microgravity; (4) explore new research applications of the biological target materials and new technology innovations; and (5) define and develop analytical methods and requirements for biotechnology research facilities planned for the U.S. Space Station. The Bioprocessing Research Center at the University of Texas Health Science Center (UTHSC) will perform portions of the research and coordinate the projects among several major universities and medical schools. Access to the CFES Unit will be provided by the McDonnell Douglas Astronautics Co. (MDAC) under subcontract to the University of Texas Health Science Center. JSC will analyze results, coordinate scientific communications, and aid principal investigators in using the information in the conduct of on-going flight experiments. Scientific data will be used to formulate new proposals for flight experiments or ground-based applications of the technology.

W88-70478 **674-23-08**
Marshall Space Flight Center, Huntsville, Ala.
BIOTECHNOLOGY
R. S. Snyder 205-544-7805

The long-range objective is to utilize the environment of space to separate, purify or crystallize, and analyze biological products. The intermediate objectives are to develop the required technology and to expand the base of knowledge involved with processing biologicals in space; to identify, evaluate, and select the most promising processes; and to explore new areas of separation technology. Separation and purification procedures which have been found to produce inadequate results on the ground because of gravity-dependent problems will be investigated. More specifically, this program will: (1) determine possible advantages of the low-gravity environment for separation, purification, crystallization, and characterization of biomedical materials; (2) design, develop, manufacture, and test experiment apparatus to conduct experiments in low gravity; (3) apply ground/flight knowledge to the improvements of bioprocessing procedures on earth; (4) develop broad and strong collaborative interactions with research scientists; and (5) identify and explore new techniques of separation or bioprocessing that might be enhanced by low gravity.

W88-70479 **674-24-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COLLISION AND COALESCENCE OF FREE DROPS
T. G. Wang 818-354-6331

The objective of this RTOP is to study three aspects of the collision and coalescence of free drops: time-dependent deformation, film drainage, and drop stability after coalescence. The results of the investigations will be used to verify existing linear theory, and to provide the necessary insight for further theoretical development of the subject. The deficiencies of the existing theory, which disregards non-uniformity of the air-film drainage, irregularity in the surface of separation, rotational energy, and oscillation energy, are exemplified by inconsistent results appearing in the literature. In the coming years, the experimental technique and procedures, data acquisition and processing will be developed in ground-based immiscible systems and in the low gravity environment provided by KC-135 flights. These results will be used to provide detailed definition of the approved space flight experiment, Collision and Coalescence of Free Drops, by T. G. Wang, D. D. Elleman, and E. H. Trinh, and will determine the appropriate hardware to obtain the optimum results from the space experiments.

W88-70480 **674-24-06**
Langley Research Center, Hampton, Va.
PACE FLIGHT EXPERIMENTS
Joseph C. Moorman 804-865-3661

The basic purpose of the PACE (Physics and Chemistry Experiments in Space) program is to facilitate the utilization of space as a laboratory in which to carry out basic research in the areas of physics and chemistry. There are currently 15 experiments in the program in the areas of fluid physics, critical phenomena, combustion, soil mechanics and relativity. The objective of this RTOP is to provide the support to these 15 experiments required to facilitate their development through the conceptual design phase and to support them through the flight development phase with Science Peer Reviews and Science Peer Advocacy.

W88-70481 **674-25-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
METALS AND ALLOYS
D. D. Elleman 818-354-5182

The Metals and Alloys RTOP consists of five tasks. The Electrostatic Containerless Processing Technology task objective is development of the science and technology base required for contactless positioning and manipulation of various materials using electrostatic and electrophoretic forces. Experimental and theoretical investigation is being conducted for the following systems: a focused radiator furnace and a hot wall furnace for the heating of low density samples up to 2000 C both in a vacuum and in a gaseous environment, feasibility study of multiple sample levitator by a single servo controller, crystal growth from levitated solution droplets by vapor diffusion, and liquid drop dynamics with surface charge near the Rayleigh limit. The Containerless Studies of Nucleation and Undercooling task objectives are to utilize containerless manipulation technologies to perform undercooling and heterogeneous nucleation experiments on low melting pure metals and alloys and organic compounds and glass formers, and measurements of the physical properties of undercooled melts. Experimental methods are based on acoustic levitation techniques using gaseous and liquid hosts. The Metallic Glass Research in Space task objective is to develop an experiment to determine thermodynamic properties of bulk metallic glasses over the entire undercooling region. The primary scientific objective is to measure the specific heat of undercooled bulk metallic glass systems. Other objectives include measurements of the rate of homogeneous nucleation and the evaluation of crystal melt interfacial tension and, in the long term, development of metallic glasses into a viable industrial and commercial material. The Multimode Acoustic Research task objectives are to develop theoretical acoustic models of new multimode classes of acoustic levitation, and to provide experimental validation of these models. These new levitation principles, coupled with advanced heating techniques, provide us with alternative methods for positioning and manipulating molten materials, which may lead to rapid cooling, separation of levitation and rotation capabilities, and the selection of arbitrary axes of rotation. The ultimate goal of this task is to enhance multimode levitation techniques for use in high temperature acoustic levitators.

W88-70482 **674-25-08**
Marshall Space Flight Center, Huntsville, Ala.
METALS AND ALLOYS
R. J. Naumann 205-544-7755

Control of the solidification of metals and alloys is keyed to gravitational effects such as buoyancy-driven convection. Thus, the objectives of the study are to: (1) identify various aspects of solidification phenomena that may be affected by gravity-driven flows; (2) devise and conduct critical experiments in both increased gravity and in space; and (3) impact the field of metallurgy by fundamental knowledge through devising better control strategies. Multicomponent metallic systems involve a first-to-freeze component which nucleates and begins to grow, causing the composition ahead of the solidification front to change dramatically. Where it is infeasible or undesirable to provide controlled gradients for a planar solidification front, dendritic growth results. Thus, concentration is one of the more fundamental problems involved in the formation of dendrites. Directional solidification affords a degree of control because unidirectional thermal gradient can be imposed and growth rate regulated. Another important class is the monotectic alloys which have a region of immiscibility. Finally, nucleation and rapid solidification of deeply undercooled melts will be pursued by containerless melting and solidification.

W88-70483 **674-26-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLASS RESEARCH
G. F. Neilson 818-354-6365

The objective of this RTOP is to establish the scientific framework for the identification and evaluation of potential flight experiments via modeling based upon the results of ground-based experimentation. The work in FY88 will be conducted both at JPL (tasks A and D) and at the University of Arizona by M. Weinberg under subcontract (tasks B and C), and will be pursued in the areas of crystal nucleation and growth processes in conventional glasses and of homogeneity in gel precursors and gel-derived glasses. The specific goals for FY88 are: (1) to examine the temperature dependent homogeneous crystal nucleation behavior in lithium diborate glass--this will involve both experimental studies and data evaluation and theoretical calculations; (2) to elucidate the structures of T-T-T diagrams for the crystallization of a single phase, accounting for complex crystal nucleation and growth behavior; (3) to evaluate the Johnson-Mehl-Avrami Law for fraction crystallized, X(t), via computer simulation methods; (4) to conduct a small-angle X-ray scattering (SAXS) and spectroscopic analysis of gel and gel-derived glass homogeneity.

W88-70484 **674-26-08**
Marshall Space Flight Center, Huntsville, Ala.
GLASSES AND CERAMICS
E. C. Ethridge 205-544-7767

The objectives of this activity are to: (1) explore novel techniques and applications for containerless processing of glasses and refractory materials; (2) understand the limitations imposed by the gravitational field; and (3) evolve meaningful flight experiments which extend processes beyond gravity limitations. For example, with metals research the recent attention drawn to containerless processing by the Microgravity Science and Applications (MSA) program has served to focus these activities and demonstrated their usefulness to a wide variety of research disciplines. In this manner, the technology of containerless processing is emerging from isolated experimenters investigating individual research tasks to a concerted multidisciplinary effort to develop better techniques and apply them to a variety of research topics. A developing scientific community is utilizing state-of-the-art ground-based levitation experiments to process many metal systems. The difficulty in levitating and melting glasses and ceramics in one-g has limited the development of this discipline. Focused heating techniques need to be developed and implemented on the 34 and 100 m drop tubes in order to be able to containerlessly solidify glasses and refractory oxides and stimulate interest in the community of glass and ceramic scientists.

W88-70485 **674-28-08**
Marshall Space Flight Center, Huntsville, Ala.
GROUND EXPERIMENT OPERATIONS
A. M. Dorries 205-544-7764

This RTOP covers work in the area of defining, developing, and conducting experiments using the low-gravity capabilities of the drop tube, drop tower, KC-135, and F-104 aircraft. Such experiments may be in themselves complete investigations to develop new knowledge or to prove theories, or they may serve as precursors for more extensive experiments to be conducted in space. This RTOP also includes studies and experiments to define the effects of various levels and durations of acceleration perturbations on microgravity experiments.

W88-70486 **674-29-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MICROGRAVITY SCIENCE AND APPLICATIONS PROGRAM SUPPORT
T. G. Wang 818-354-6331

The objective of this RTOP is to develop and implement program plans and joint Centers Agreements for the Microgravity Science and Applications Program. These plans will provide the guidance for ground-based and space flight experiments to develop a solid foundation for future activities of Microgravity Science and Applications (MSA) operations. JPL has already been working on this activity and the effort will be expanded. The Joint Centers Agreement document was completed during FY87 with coordination between JPL and NASA Headquarters. This activity has continued per the plan submitted to NASA. The basic scientific investigations will continue at JPL and universities.

W88-70487 **674-29-08**
Marshall Space Flight Center, Huntsville, Ala.
CONSULTING AND PROGRAM SUPPORT
B. G. Bass 205-544-7756

The objectives of this RTOP are to provide the necessary management and support manpower to implement the Microgravity Science and Applications (MSA) research and technology development effort; and to provide the MSA program with an effective means of interacting with the various scientific communities involved for the purposes of: (1) making them aware of the research opportunities offered by the MSA program; (2) stimulating their interest and active involvement in the program; (3) gauging their response to the scientific results being obtained by the program; (4) identifying research areas in which the program should concentrate; (5) initiating in-house research activities in selected topics pertinent to the MSA program; and (6) evaluating the ongoing research effort. MSFC will ensure the necessary professional and supporting manpower to implement the MSA research and technology development effort. Also, the stated objectives will be met by actively involving the various research communities in the MSA program through working groups, seminars and workshops, science reviews, and a visiting scientist program. In addition, scientific goals and accomplishments of the program will be documented and disseminated to the science communities in the form of a published bibliography and catalog of tasks.

Geodynamics Research and Technology Development

W88-70488 **676-10-10**
Goddard Space Flight Center, Greenbelt, Md.
SOLID EARTH DYNAMICS
Steven Cohen 301-286-8826

The objective of this RTOP is to conduct research and provide support for research relating to the solid earth, its dynamics, structure and interior composition. We will pursue research aimed at determining the lithosphere's present state and evolution and its physical properties. The large-scale structure and magnetization contrast between the continental and oceanic lithosphere will be determined using Magsat data. We will conduct studies of the measurements and systems necessary for future geophysical and geodetic measurements of the earth and planets. The relationships between petrogenesis and tectonics will be determined. We will provide technical and administrative management for grants and contracts in geodynamics and prepare and exercise a geodynamics management data base. Finite element models of earth dynamic processes including continental collisions and postglacial rebound will be developed and used to deduce earth structure and rheology. A study will be performed of lithospheric flexural rigidity in Australia based on gravity-topography coherence.

W88-70489 **676-30-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
POLAR MOTION AND EARTH MODELS
T. M. Eubanks 818-354-7218

The objective of this research is to obtain a better understanding of the physical processes which influence earth rotation and polar motion. To obtain our goals, our investigation is divided into three separate tasks. Task 1, Atmospheric Dynamics and the Excitation of Earth Orientation Changes, will involve comparison of publicly available estimates of the earth orientation and the total atmospheric angular momentum with various

meteorological data sets. A major goal of this task will be to verify the connection between changes in the equator to pole temperature gradient and changes in the length of day (the 50 day oscillations, the seasonal variations, and the longer period changes correlated with the Southern Oscillation). The dynamical causes of any such relationship will be investigated. Under Task 2, Numerical Simulations of Atmospheric Angular Momentum Changes, the so-called 50 day oscillation in earth rotation and in the atmosphere as well as diurnal atmospheric tides will be investigated by the use of a general circulation model of the atmosphere to provide insight into solid earth-atmosphere interactions. Task 3, Data Quality Enhancement and Verification, is intended to improve the quality and reliability of estimates of the excitation of changes in the earth orientation. Estimates of the atmospheric excitation of earth orientation changes from independent weather forecast centers will be analyzed to provide indications of the accuracy of these data. Surface pressure data will be used to estimate the size of the water vapor accounting error. Errors in the inverted barometer model of the ocean response will also be evaluated. Part of the atmospheric excitation of earth orientation changes results from surface pressure changes. Pressure-derived excitation estimates will be used to calculate changes in the low order spherical harmonics of the surface pressure for comparison with satellite tracking data.

W88-70490 **676-40-02**
Goddard Space Flight Center, Greenbelt, Md.
SOLAR RADIUS/LUMINOSITY STUDIES
E. Maier 301-286-8912

The major objectives of this RTOP are to develop more accurate and reliable models of the earth's main magnetic field and its temporal variation, to study the physical processes in the core which are responsible for generation of that field, and to conduct studies preparatory to proposed missions. The approach includes both collection of all suitable data types and the development of new analytic techniques. New observatory and repeat data are being added to our data set as they become available. During the past year a proper error analysis for the spline function representation of secular variation was implemented and used to project Magsat data to earlier epochs as a priori for international geomagnetic reference field (IGRF) calculations. The formalism for error analysis was, and is being, refined and tested. Characteristics of the 1970 jerk were modeled and the results published. Data from the DE-2 satellite and from the Air Force DMSP F-7 spacecraft were acquired. DMSP F-7 continues to operate and we will continue to receive the data. Acquisition of data from other spacecraft (e.g., AMPTE, Polar Bear, etc.) is being pursued. A model for 1980 to 1986 is under preparation which has the possibility for being the most accurate short term secular variation model to date. New formalisms for external field analysis will be implemented to take advantage of the accuracy of Magsat data. Present approaches to representation of the temporal variation are inadequate. Periodic functions and cubic splines are among the candidates for a new representation. Models with a priori based on the physics of the core (Stochastic Inversion) will be explored. Models of the fluid velocity at the top of the core will continue to be explored assuming steady motion and/or geostrophy and, for the first time, flux diffusion.

W88-70491 **676-40-10**
Goddard Space Flight Center, Greenbelt, Md.
SOFTWARE DEVELOPMENT SUPPORT
Barbara H. Putney 301-286-6018

The objective of this RTOP is to develop a model of the earth's gravity field based upon satellite tracking and altimetry and surface gravity data. The computed geopotential model, the interim field, will be used as the a priori model at the beginning of the Geopotential Research Mission (GRM). State-of-the-art geodynamic software systems will be developed and research will be performed through the interpretation of geopotential signals. Studies will be conducted of a spaceborne gravity gradiometer system for earth/planetary mapping of the gravity field. Flight concepts will be evaluated for a cryogenic gravity gradiometer using the Spartan configuration. A GRM local solution simulation will be developed using University of Texas gravity model and establish orbit constraints from matrix inversion techniques. Essential elements for the development of the interim field are: improvement in methods of incorporating surface gravity data; development of techniques for extensive use of altimeter data; improvement of accuracy of models used on orbit determination; and optimization of the necessary software programs. The gradiometer studies are to focus on covariance analyses, simulation studies, hardware design, and engineering studies. The GRM simulation will use the University of Texas observation signal (180 x 180 field) and recover the gravity model and estimate its accuracy both in the local and global sense. Improved accuracy in features of the gravity field is expected to reduce the overall error of the geoid by about 50 percent. The gradiometer studies evaluate the gradiometer as a gravity mapping tool. Results from the GRM studies will consist of a global set of harmonic coefficients, local region gravity anomalies (1 deg x 1 deg), and orbital constraints on the satellites.

W88-70492 **676-59-10**
Goddard Space Flight Center, Greenbelt, Md.
GEOPOTENTIAL RESEARCH MISSION (GRM)
T. Keating 301-286-8817

The objective of this RTOP is to perform two engineering studies of a new configuration GRM: design and analysis of the configuration known as the two-stage Disturbance Compensation System (DISCOS) and design and analysis of the inclusion of a gravity gradiometer onto the spacecraft. The effort is a continuation of the FY87 augmented RTOP. The design of the GRM will be sufficiently defined to determine expected performance for comparison with the scientific objectives and to allow cost estimation. The studies will serve as the basis for a Phase-A study, will show performance capability, and will allow mission cost estimation.

W88-70493 **676-59-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GRAVITY FIELD MISSION STUDIES
D. Sonnabend 818-354-7593

The objective of this work is to continue the development of a technique for operating sensitive instruments, primarily gravity gradiometers, aboard the Space Transportation System (STS) vehicle (Shuttle). The technique provides either active vibration isolation or intermittent drag free operation of the payload instrument, with minimum impact on Shuttle systems or operations. The payload would be encased in a conducting shell, and set free inside a set of eddy current forcing coils. In the vibration isolation mode, the payload position is continuously fed back to the forcing coils, using arbitrary frequency shaping. In the semi drag free mode, the coils are operated only briefly, when collision with the coils is imminent. Previous studies have shown that normal Shuttle disturbances, including air drag, rotation, and crew motion can all be accommodated, and determined the special requirements associated with cryogenic payloads. Work is presently underway to demonstrate single axis operation in the laboratory, and to examine the possibility of remote identification of the instrument parameters, in the laboratory and in flight.

W88-70494 **676-59-31**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GPS MEASUREMENT SYSTEM DEPLOYMENT FOR REGIONAL GEODESY IN THE CARIBBEAN
William G. Melbourne 818-354-5071

A new measurement system for centimeter geodesy is being developed and demonstrated in California, Mexico, and the Caribbean. The broad objective is to achieve baseline accuracies of 2 cm in the local vertical and 1 cm in each horizontal component over distances up to 1000 km in order to conduct key geodetic experiments in regions of tectonic interest. Among the problems to be addressed are: (1) the question of the direction and rate of relative motion between the North American and Caribbean plates; (2) the subduction of the Cocos plate beneath Central America;

(3) the spreading rate across the Galapagos spreading center; (4) the spreading rates in the Gulf of California; (5) the nature of strain in southern California; and (6) uplift and deformation in the Long Valley caldera associated with magna injections. System development will continue to build on the successful demonstrations and technology development conducted in the FY85-FY87 time frame. A fully operational Global Positioning System (GPS) data processing software system (GIPSY), which derived a high inheritance from the very long base interferometry (VLBI) and Planetary Navigation systems, has been completed. Improved strategies for data analysis and experiment planning have led to significant improvements in system accuracy that is now approaching a few centimeters or less. Improved field equipment, including advanced GPS receivers, antenna systems and water vapor radiometers, are now beginning to be deployed in field experiments. These elements should lead to 1 to 2 cm system accuracies over the next few years.

W88-70495 **676-59-32**
Goddard Space Flight Center, Greenbelt, Md.
LASER RANGING DEVELOPMENT STUDY
J. J. Degnan 301-286-7714
(676-10-10; 692-20-10)

The long-term goals of this RTOP are to develop automated millimeter accuracy satellite laser ranging (SLR) systems and to provide supporting analyses and technology tradeoff studies in support of a combined geodynamics/altimetry mission of the Geodynamic Laser Ranging System (GLRS) instrument on the Earth Observing Satellite (EOS). The technical strategy is to use dual wavelength, subnanosecond pulse laser transmitters and picosecond resolution streak camera technology to remove centimeter level range uncertainties caused by atmospheric refraction effects. Quadrant or imaging detectors will be incorporated into the system to permit totally automated star calibrations. Analytical studies of the limiting effects of speckle from existing targets such as Laser Geodynamic Satellite (LAGEOS) on ranging accuracy will be carried out. Under this RTOP, earlier system studies of the GLRS will be updated to provide a preliminary assessment of the engineering impact of an additional, high duty cycle altimetry mission. Different altimetry missions vary in their data type (e.g., simple mean range vs. return waveforms for surface roughness investigations) and data volume which can impact transmitter energy and lifetime specifications and receiver design. We will investigate the GLRS instrumental changes dictated by a combined two-color geodynamics and altimetry mission and also potential improvements to the instrument made possible by recent technological advances in the areas of laser pumping, high speed photodetectors and spacecraft navigation.

W88-70496 **676-59-33**
Marshall Space Flight Center, Huntsville, Ala.
SUPERCONDUCTING GRAVITY GRADIOMETER
S. H. Morgan 205-544-0614

The objective of this RTOP is to develop a full vector, three-axis superconducting gravity gradiometer for space flight applications. The instrument will be designed to have a measurement sensitivity of 1/10,000 Eotvos unit (1 Eotvos unit = one billionth of a second per second) in an orbital environment and exhibit a measurement time constant consistent with the current requirements of geodynamics research. The final functioning sensor unit will be constructed and tested in a manner consistent with a proto-flight approach to a possible precursor Shuttle flight test.

W88-70497 **676-59-45**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GPS POSITIONING OF A MARINE BUOY FOR PLATE MOTION STUDIES
T. H. Dixon 818-354-7535

This RTOP is intended primarily to perform a system analysis and demonstration of the use of GPS (Global Positioning System) receiver technology for determining the location of an ocean surface platform with respect to the GPS reference frame. The development of a system for measuring the location of benchmarks on the ocean floor with respect to an acoustic transmitter on the surface platform is being performed under other Geodynamics Program-sponsored research, by F. N. Spiess of Scripps Institution of Oceanography. The combined objective of these two RTOPs is to precisely tie ocean floor benchmarks to an earth fixed reference frame. GPS-based systems have been developed for high precision, cost effective geodetic measurements under the NASA Geodynamics Program. Current proof-of-concept receivers have demonstrated baseline measurements with few cm accuracies. If this level of performance can be maintained in a system used at sea, it will be adequate for obtaining an absolute position for the surface element(s) of an acoustic sea floor benchmark system. Moreover, the instantaneous positioning data for the surface element of the array obtainable with GPS may enable us to put limits on the sound velocity variation in the upper 100 m of water measured. Variability in this layer is expected to be a major error source. Some developments in the system design are required to use GPS technology for sea floor geodesy. These include antenna design, determining instantaneous positions and orientations of a wave-tossed platform. Preliminary sea trials with the SERIES GPS receiver and over-water tests with the TI-4100 receiver have been used to gain engineering information. Data on platform acceleration, outages caused by obstructions RFI levels, and multipath from the ocean surface are being used to set GPS receiver and baseline solution software design parameters. GPS receivers selected for this system will be tested initially on fixed baselines and eventually tested during sea trials of the acoustic positioning equipment.

W88-70498 **676-59-75**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED MAGNETOMETER
E. J. Smith 818-354-4110

The objectives of this RTOP are to: (1) demonstrate that the helium magnetometer can be operated in a scalar mode which satisfies the requirements of the Geopotential Research Mission (GRM), the Magnetic Field Explorer (MFE), Tethered Satellite Systems (TSS) and similar future missions; (2) to demonstrate that the helium magnetometer can be operated in a dual scalar and vector mode and fulfill the requirements of these missions; and (3) to evaluate a He-3 nuclear free-precession magnetometer which has the potential of providing extremely accurate magnetic field measurements with a very light-weight, low-power instrument. A team of both theoretical and magnetic field instrument experts has been assembled and is working to attain the above objectives. The theoretical team, consisting of scientific experts involved in helium magnetometers since their inception, has determined the theoretical limits of the scalar helium magnetometer. The instrumentation team has designed and fabricated instrumentation capable of attaining these limits.

W88-70499 **676-59-80**
Goddard Space Flight Center, Greenbelt, Md.
MAGNOLIA/MAGNETIC FIELD EXPLORER
G. W. Ousley, Sr. 301-286-8073
(676-59-10)

The objective of this RTOP is to conduct system definition studies for a Magnolia/MFE (Magnetic Field Explorer) mission. The studies will be based on the Magsat-A concept and will build on the studies completed by APL. The studies will produce the U.S. inputs for a definition phase spacecraft design with the French CNES that could serve as the basis for a joint cooperative program. The French Centre National d'Etudes Spatiales (CNES) is cooperating with NASA in this study activity which could lead to a joint mission on the Ariane launch vehicle.

Resource Observation Applied Research and Data Analysis

W88-70500 **677-21-00**
Ames Research Center, Moffett Field, Calif.

GLOBAL BIODIVERSITY: HABITAT CHANGE AND SPECIES EXTINCTIONS

W. E. Westman 415-694-5299

(199-30-00)

The objectives of this RTOP are to quantify recent rates and locations of change of major habitat types over large portions of the global terrestrial landscape (with initial focus on the tropics) and to predict changes in endangerment status of species in major taxonomic classes as a result of the observed habitat alteration. Rates and locations of habitat clearing at large scale of spatial resolution will be determined using satellite imagery (initially Advanced Very High Resolution Radiometer data). Numbers of species lost in mammalian, bird, butterfly and vascular plant groups as a result of habitat reduction will be estimated using species area relations. Changes in endangerment status of species within these groups will be predicted based on known endangerment status from field records, habitat preferences, biogeographic distributions, and ecological attributes indicative of the species response to habitat fragmentation, encoded in a georeferenced database. Coarse-scale predictions will be validated using field data records. Further validations both of habitat change and species loss will be conducted by means of fine spatial-scale image analysis and field studies at intensive study sites. A spatially based computer simulation model of species endangerment processes will be constructed and tested with data from intensive study sites.

W88-70501 **677-21-02**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

DETECTION OF REGIONAL CHANGE IN FORESTS OF THE NORTHEASTERN UNITED STATES USING LANDSAT REMOTE SENSING DATA

J. E. Vogelmann 818-354-6927

The primary objective of this RTOP is to determine by use of orbital remote sensing systems the degree of change in state of health of coniferous and deciduous forests in the northeastern United States since the early 1970s. The forests of this region have experienced dramatic declines over this time period, especially at the higher elevations, and it is suspected that inputs of pollutants into these high elevation ecosystems are involved. It is proposed that Landsat Multispectral Scanner Subsystem (MSS) data from separate years (e.g., 1973, 1976, 1981, 1984) be compared. It is also proposed that data from Landsat Thematic Mapper (TM) be compared (e.g., 1984 vs. 1987). Changes in reflectance for individual bands will indicate where major vegetation changes have taken place. Thus, it is anticipated that the study will provide information as to magnitude and spatial patterns of the forest decline process, and also indicate which plant communities are involved. Cloud-free quality Landsat MSS and TM data will be acquired for a portion of the northeastern U.S. to include Camels Hump Mountain, Vermont. This is a site for which much ground-based vegetational data have been collected since the early 1960s. Remotely-sensed data to be compared will be from different years. Comparisons will be made among data sets representing comparable phenological conditions, sun angle and azimuth. Thus, data to be used will be from approximately the same time of year (e.g., late August). Data will be co-registered and calibrated using ground-based reflectance measurements from calibration targets. Difference images will then be produced, which will indicate where major vegetation changes have occurred. Another approach employing Principal Components analysis will also be used to create images depicting regions of change. Results will then be field-checked and compared with data from Camels Hump Mountain.

W88-70502 **677-21-21**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

WATERSHED EVAPOTRANSPIRATION: NONSTEADY-STATE MODEL USING MULTISENSOR DATA

E. R. Hunt, Jr. 818-354-1917

The objectives of the investigation are: (1) to develop a physiologically realistic nonsteady-state model of evapotranspiration (ET)and water flow through the soil-plant-air continuum; (2) to develop methods of remotely sensing model parameters using a combination of sensors that will be on the Earth Observing System (EOS); and (3) to test this model by comparing predicted ET from overflight data with actual ET of evergreen-chaparral watersheds. Model parameters and variables will be estimated using thermal infrared to estimate transpiration rate, visible and infrared to measure chlorophyll density and leaf water content, and C-band and L-band radar to measure woody biomass. NS-001 Thematic Mapper Simulator (TMS) overflights will be used to estimate ET from plentiful water conditions (active transpiration) to summer drought conditions (no transpiration), in order to compare predicted ET with measured ET of several watersheds at the San Dimas Experimental Forest, California. Field studies will characterize plant biophysical properties for comparison with remote sensing inputs.

W88-70503 **677-21-24**

Goddard Space Flight Center, Greenbelt, Md.

TERRESTRIAL ECOSYSTEMS

Ross F. Nelson 301-286-9925

The purpose of this study is to assess a variety of biological and physical components of complex terrestrial ecosystems such as forests using remotely sensed data. A variety of remote sensing tools will be used to address continental and regional phenomena in order to derive information concerning the areal extent and composition of forests. Spaceborne, spectral data have been and are being acquired in order to develop the statistical techniques and procedures necessary to integrate Advanced Very High Resolution Radiometer (AVHRR) Global Area Coverage (GAC) and Multispectral Scanner Subsystem (MSS) digital-data for continental resource assessment. The fine resolution MSS data are used to adjust or correct estimates of forest area derived using AVHRR 4 km data. A statistical approach for subcontinental/continental assessment of natural resources using multiresolution, multisensor digital imagery will be developed and tested. An expert system will be developed and tested which will permit the identification and enumeration of level 1 and, perhaps, level 2 forest cover types using AVHRR normalized difference vegetation index (NDVI) temporal profiles.

W88-70504 **677-21-25**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

MULTISENSOR ASSESSMENTS OF FOREST DECLINE

J. F. Paris 818-354-6936

The objective of the remaining two-years of the continuing RTOP is to assess forest conditions and the change in forest conditions in montane boreal forests (two 10 x 10 km sites in the northeastern U.S.). We propose to use a combination of long-wavelength active-microwave image data from the Airborne Imaging Radar Polarimeter (AIRP) and optical image data from the NS001 Thematic Mapper Simulator (TMS) or equivalent in our assessments. Also, the former PI, Dr. B. N. Rock, is leaving JPL to go to the University of New Hampshire (UNH) to continue his work under this RTOP with funding from a direct contract between NASA and UNH. Therefore, we are making a significant change in the scope of the original RTOP both with regard to the nature of the work and to the budget required. We (the new PI and new Co-I) plan to cooperate with Dr. Rock's continuing research in the same test sites (Camels Hump Test Site, Vermont, and Whiteface Test Site, New York). We plan to use the expected information from the AIRP (woody biomass, stem angle, leaflet size, substrate wetness, and stand gap-properties) in combination with the expected information from the optical sensors (foliar biomass and leaf relative water content) to improve the estimation of forest condition (compared to optical data alone) for both cover-type estimation and forest condition estimation.

W88-70505 **677-21-31**

Ames Research Center, Moffett Field, Calif.

FOREST EVAPOTRANSPIRATION AND PRODUCTION

D. L. Peterson 415-694-5899

(677-21-35; 199-30-72)

The objectives are to determine evapotranspiration (ET) and net primary productivity (NPP) for a large regional coniferous forest, to test extrapolation limits of ecosystem process models of ET and NPP, and to test theories necessary for efficient partitioning and aggregation of a forested landscape to support regional level estimations. The strategy is to implement an appropriately modified version of DAYTRANS/PSN, an existing physiologically based model simulating ET and NPP at the conifer stand level, for initially a small watershed and later a 2600-square-kilometer basin in Western Montana. Variables relating to key processes controlling energy, carbon and water exchange will be derived from remote sensing, digital terrain, in-place measurement, and soil data. The variables, to be interrelated in a geographic information system, are: (1) site physical properties (slope, aspect, elevation, soil) obtained by automated partitioning of the terrain into hydrologically meaningful landscape units; (2) surface meteorological conditions including radiation balances, canopy/air temperature, humidity, precipitation; and, (3) vegetation characteristics, leaf area index and total biomass. Estimates of ET and NPP will be validated using independent hydrologic yield measurements and productivity estimates from ground sampling.

W88-70506 **677-21-32**
Goddard Space Flight Center, Greenbelt, Md.
GLOBAL INVENTORY MONITORING AND MODELING EXPERIMENT
Compton J. Tucker 301-286-7122
(199-30-99)

The objective of this RTOP is to develop the techniques and scientific basis for studying terrestrial renewable resources at regional, continental, and global scales with multilevel satellite remote sensing data. Satellite data will be obtained at spatial resolutions of 30m, 80m, 1km, 4km, and 15km for selected local areas (30 and 80m), regional test sites (1km), continental test areas (4 and 8km), and the entire planet (15km). These data will be analyzed to provide high temporal frequency vegetation biomass and condition information for assessing productivity, land cover mapping, deforestation, insect and disease upsurges, and other large-scale vegetation information of interest to global science questions such as the earth's radiation budget, the carbon cycle, and the hydrological cycle. Expected results include: (1) understanding of large-scale vegetation response and its relationship to atmospheric and climatic phenomena; (2) estimates of grassland biomass production across entire continental ecological zones; (3) global estimates by continent of land cover types and how these vary with time; (4) improved documentation of tropical deforestation and estimates of forest spatial extent for selected tropical and boreal forests; (5) understanding the coupling of directional reflectance and atmospheric effects; (6) developing the computer-related software to process large volumes of coarse resolution satellite data and handle multilevel satellite data from the same target; and (7) determination of desert boundaries and desert spatial extent.

W88-70507 **677-21-34**
Ames Research Center, Moffett Field, Calif.
IMAGE PROCESSING LABORATORY FOR TERRESTRIAL ECOLOGY
W. C. Likens 415-694-5596
(199-30-00)

The Image Processing Laboratory (IPL) supports the computer analysis of biospheric and terrestrial ecological data. Remotely sensed images are a primary data source for these studies. Operation of the IPL requires ongoing equipment replacement and upgrades to the facility. Tasks under this RTOP provide for the upgrade of the IPL facility. Additional IPL support is also proposed under the related RTOP.

W88-70508 **677-21-35**
Ames Research Center, Moffett Field, Calif.
BIOGEOCHEMICAL CYCLING IN TERRESTRIAL ECOSYSTEMS
D. L. Peterson 415-694-5899
(199-30-72; 677-21-31; 199-30-62)

The objectives of this research are: (1) to develop and use theoretical models and empirical studies to derive biochemical information from leaf and canopy spectra; (2) to relate these measurements to ecosystem productivity and nutrient cycling for temperate and tropical gradients; (3) to incorporate these findings into developing ecosystem process models; (4) to determine the biochemical and biophysical response to airborne pollutants in select ecosystems; and (5) to relate flux measurements of methane and other trace gases from arctic tundra ecosystems and model manganese cycling in freshwater lakes. The approach will be: (1) to develop deconvolution and biophysical models of leaf spectral characteristics accounting for biochemical properties; (2) to apply these techniques to canopy models to understand the canopy chemistry in empirical remote sensing studies using visible to shortwave spectral sensors such as the Airborne Visible and Infrared Imaging Spectrometer (AVIRIS); (3) to design, conduct and compare gradient studies of ecosystem nutrient cycling using established methods and incorporate in ecosystems models combining water-carbon-nutrient processes and interactions and test for generality; (4) conduct spectral, chemical and anatomical analyses on fumigated and naturally occurring pollutant damaged plants and ecosystems; (5) measure methane and other trace gases from sample sites optimally selected from remote sensing analyses of tundra ecosystems and extrapolate to large scale using multistage methods and input to atmospheric model; (6) measure lake processes related to manganese cycling; and (7) relate to remote sensing data and extrapolate.

W88-70509 **677-21-36**
Goddard Space Flight Center, Greenbelt, Md.
BASIC LAND SYSTEM STUDIES
David L. Toll 301-286-9256
(677-92-22)

The objective is to provide the broad range of programmatic and technical supporting activities necessary for the conduct of basic studies of the land surface as a system, including those in support of the International Satellite Land Surface Climatology Program (ISLSCP). An active satellite data base will be built for use by ISLSCP investigators. Meetings and workshops will be conducted to discuss and plan future directions of basic land system studies such as those for ISLSCP. Some supporting research will be conducted, including bidirectional reflectance field measurement experiments in the U.S. and AVHRR thermal data analyses for land-climate interaction studies of African study sites. Documentation describing the results of the meetings and workshops will be prepared, printed, and distributed to interested parties. NOAA AVHRR and Landsat MSS and TM data sets of interest to ISLSCP investigators will be purchased and distributed, as appropriate, and retained in a local data base for future use. Test measurements acquired during the field campaign will be analyzed, and results will be used to refine field experiment data acquisition techniques.

W88-70510 **677-21-36**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SATELLITE MEASUREMENT OF LAND SURFACE PARAMETERS FOR LAND STUDY
E. G. Njoku 818-354-5607

Research is under way to evaluate the potential of three different satellite sensors for measuring parameters of use in land surface climatology studies. The sensors are the Scanning Multichannel Microwave Radiometer (SMMR), the High Resolution Infra-Red Sounder/Microwave Sounding Unit (HIRS/MSU), and the Advanced Very High Resolution Radiometer (AVHRR). Data from these instruments can be used to provide information on surface soil moisture, temperature, and vegetation cover, all of which are key parameters in models of energy exchange at the land-atmosphere boundary. Time-series of derived data from these sensors will be compared for complete seasonal cycle over the same geographic locations, primarily the African Sahel, in order to quantify the relationships between sensor measurements and surface features. Results will lead to better use of satellite data in understanding and monitoring climate change, and will form part

of the recently-initiated International Satellite Land-Surface Climatology Project (ISLSCP).

W88-70511 **677-21-37**
Goddard Space Flight Center, Greenbelt, Md.
STUDIES OF THE INFLUENCE OF ANOMALIES IN THE BIOSPHERE ON CLIMATE
Yogesh Sud 301-286-7408

The objective of this RTOP is to examine the role of biosphere atmosphere interactions on the atmospheric circulation and rainfall fields. The new biosphere model will be used to simulate January and July conditions. The model's influence on circulation and rainfall will be compared to the standard GLA model and analyzed in the light of its influence on surface fluxes of heat moisture and momentum. The SiB model is being vectorized for future simulation studies as outlined in the proposal. Expected results include theoretical and numerical studies that improve our understanding of earth atmospheric feedbacks and drought promoting mechanisms in the Sahel and the role of deserts in local and global circulations.

W88-70512 **677-21-40**
Goddard Space Flight Center, Greenbelt, Md.
FOREST ECOSYSTEM DYNAMICS
James A. Smith 301-286-7282

The overall objective of the research is to use forest pattern and process models, soil models, and radiative transfer models, combined with ground-based and satellite observations to understand the dynamics of boreal forest ecosystem evolution over a variety of temporal and spatial scales. A key component of this effort is the involvement of the scientific community at large in studies to couple forest ecosystem dynamics to large scale environmental changes. Two major tasks are involved: the synthesis and organization of available knowledge of forest ecosystem dynamics into a comprehensive modeling framework, and the classical problem of appropriately scaling up our knowledge of ecosystem processes as we move from the site to the local to the regional and ultimately to global perspectives. Remote sensing will play a particularly crucial role in solving this latter problem. Key results of this effort will be: (1) advancement of state-of-the-art theoretical models applicable to evaluation and refinement with global satellite observational capabilities; (2) compilation of appropriate measurement sets; and (3) encouragement of scientists capable of utilizing advanced remote sensing technology for global ecosystem science problems. We anticipate that the proposed research will yield results which may have a wide ranging impact on the ecological and forestry research communities, particularly as they might relate to the NASA Earth Observing System (EOS) era.

W88-70513 **677-21-40**
National Space Technology Labs., Bay Saint Louis, Miss.
INFLUENCE OF CHEMICAL COMPOSITION, PHOTOSYNTHESIS, AND WATER RELATIONS ON LEAF SPECTRAL REFLECTANCE IN LOBLOLLY PINE (PINUS TAEDA L.)
Gregory A. Carter 601-688-1918

The objectives of the proposed study are to relate leaf spectral reflectance of sunlight to: (1) foliar concentrations of N, P, K, Mg, Fe, chlorophylls a and b, starch, and total protein; (2) leaf photosynthetic rate and photosynthetic capacity; (3) leaf water status; and (4) potential interactions among leaf chemical content, photosynthetic performance, and water status. Measurements will focus on young loblolly pines growing in sand culture so that soil nutrient levels can be effectively controlled. Fertilization treatments will induce a range of foliar nutrient levels, which will influence pigment, starch, and protein production. Concentrations of each of these chemical constituents will be related to leaf reflectance. Steady-state photosynthetic rates will be monitored in a controlled environment cuvette so that CO2 flux into the leaf can also be related to reflectance plus chlorophyll fluorescence. Drought treatments will be included to determine direct influences of water stress on reflectance, but also to evaluate possible interactive effects of water stress on radiative properties which would normally be attributed to chemical content or processes. Results will yield a greater understanding of how plant chemical components, physiological processes, and environmental factors combine to influence leaf radiative properties under solar radiation.

W88-70514 **677-22-27**
Goddard Space Flight Center, Greenbelt, Md.
HYDROLOGIC INFORMATION EXTRACTION TECHNIQUE DEVELOPMENT
R. J. Gurney 301-286-5480
(677-22-28)

The objectives of this RTOP are: (1) to determine remote sensing capabilities for observing net radiation, surface temperature, soil moisture, snowpack properties and precipitation over land; (2) to develop models that are calibrated using this remotely sensed data to estimate hydrological fluxes, such as rainfall, evapotranspiration and runoff, soil moisture profiles and soil hydraulic properties; and (3) to examine the spatial integration of these estimated variables and parameters using remotely sensed data. Remotely-sensed data to determine these variables will be obtained from field, aircraft and spaceborne measurements. Physically based models to use these data to infer the hydrological fluxes and parameters will be written and calibrated using these data and will be used to investigate the spatial variability of these quantities. Detailed distributed physically-based water balance model will be completed and tested. Calibration of energy-balance models of snowpacks with several types of remotely sensed data will be shown. Large-scale spatial variations of hydrological variables will be described statistically for input into global models.

W88-70515 **677-22-28**
Goddard Space Flight Center, Greenbelt, Md.
WATER RESOURCES CYCLING (ISLSCP)
R. J. Gurney 301-286-5480
(677-22-27)

The objective of this RTOP is to determine the capability of extracting quantitative estimates of land surface parameters from satellite radiance observations. These parameters include components of the surface energy balance such as albedo, latent and sensible heat fluxes, surface temperature and insolation. Existing satellite data will be analyzed, e.g., NOAA Advanced Very High Resolution Radiometer (AVHRR), Nimbus Scanning Multichannel Microwave Radiometer (SMMR) and Landsat Multispectral Scanner Subsystem (MSS) for land surface parameters. Coordinated field experiments will be conducted in which satellite, aircraft and surface determinations of land parameters are intercompared. These efforts will be part of the International Satellite Land Surface Climatology Project (ISLSCP). Data from the Hydrologic and Atmospheric Pilot Experiment (HAPEX) will be analyzed to estimate regional evaporation during the experiment. An eight year set of data from Nimbus-7 SMMR will be used to understand soil moisture mass balance and vegetation over the Sahel zone of Africa.

W88-70516 **677-22-29**
Goddard Space Flight Center, Greenbelt, Md.
FIRST ISLSCP FIELD EXPERIMENT (FIFE)
Forrest G. Hall 301-286-2974
(677-22-27; 677-92-22; 677-21-36)

The objective of this RTOP is to obtain the necessary data to permit interpretation of satellite observations to infer climatologically significant land surface parameters. We will acquire simultaneous satellite (Advanced Very High Resolution Radiometer, Speed Position and Track, Landsat, etc.), aircraft (spectral, material and energy flux through the atmospheric boundary layer) and surface observations of radiometric, atmospheric, meteorological, hydrological and biophysical parameters of vegetation and soil at sufficient temporal and spatial resolution and over a large enough area to permit proper comparison of satellite derived quantities with actual surface conditions.

W88-70517 **677-22-29**
National Space Technology Labs., Bay Saint Louis, Miss.
MODELING SURFACE RADIATION CHARACTERISTICS AND EFFECTS ON MESOSCALE CLIMATIC PROCESSES OVER THE GREAT SALT LAKE DESERT, UTAH
Dale A. Quattrochi 601-688-1919

This research will use Thermal Infrared Multispectral Scanner (TIMS) data acquired at multiple intervals within a diurnal period, in conjunction with data obtained from an extensive network of remote meteorological stations, to map and model surface radiation characteristics and investigate thermal influences on mesoscale climatic processes over the Great Salt Lake Desert in western Utah. TIMS data will be obtained for four specific time intervals over a diurnal period in the late spring or summer. In conjunction with these thermal IR data, a network of remote meteorological ground recording stations distributed across the Great Salt Lake Desert will provide antecedent and in situ information on heat and moisture fluxes. These comparative surface measurements will be critical for interpreting surface temperatures, soil moisture, and energy transfer from the TIMS data.

W88-70518 **677-24-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PRELIMINARY DESIGN OF A PORTABLE THERMAL INFRARED SPECTROMETER
G. Hoover 818-354-2167

The objective of this proposal is to develop a preliminary design for a Portable Thermal Infrared Spectrometer (PTIS) and, based on this design, estimate the cost of building a prototype and the schedule for such construction. The establishment of a design will be based on three elements: (1) ten years of experience using the world's only existing Field Portable Emission Spectrometer (PFES); (2) advances over this time in detectors, methods of cooling, electronics (especially microprocessors), storage devices, and display techniques; and (3) trade studies to identify the best choice in areas where there may be two or more good approaches. The first year for which funding is sought will cover the design of the instrument. There are a number of alternatives of a hardware nature which we intend to test experimentally by building bread-board versions. The ways in which we intend to improve on the currently existing spectrometer are: (1) extend the spectral range from 4.5 to 14.5 micrometers to include the 3 to 4.5 micrometer region; (2) provide a real time display capability so that the user can collect data more intelligently; (3) adopt liquid nitrogen as the detector cryogen to replace high pressure argon gas; and (4) reduce the size and weight. The second year would be devoted to the actual construction of the new instrument. It is expected that some of the fabrication would be carried out by JPL and some by outside contractors. Calibration of the instrument and preparation of comprehensive documentation would be carried out as part of the project.

W88-70519 **677-24-01**
Goddard Space Flight Center, Greenbelt, Md.
REMOTE SENSING SCIENCE PROGRAM
Harold Oseroff 301-286-9538

The Remote Sensing Science Program is conducted to improve the general scientific understanding of the energy emitted or reflected from an earth surface target, through the intervening atmosphere as measured by a remote sensing system. It is designed to provide a foundation upon which new, more advanced satellite and aircraft remote sensing instruments and interpretive techniques can be developed. At its heart is developing an understanding of the physical processes whereby radiant energy is emitted or reflected from earth land surface targets and the relationships of the measurable radiant energy to important biophysical attributes and processes. GSFC responsibility includes the project management and several of the fundamental research tasks. The approach will be to seek new research and evaluating proposals, monitor continuing studies, and conduct workshops, progress review meetings and conference technical sessions, as well as perform the necessary procurement activities in a manner similar to previous years. Continued advancement of the state-of-the-art of theoretical models that predict radiant energy response from earth surfaces and improvement in empirical characterizations that lead to the formulation of mathematical process models, which relate reflected and emitted radiation to scene attributes, are expected from this effort.

W88-70520 **677-24-01**
Ames Research Center, Moffett Field, Calif.
OPTICAL SCATTERING OF PLANT CANOPIES
J. G. Lawless 415-694-5900

The objective of this research is to determine what useful, extractable information is contained in the light reflected by plant canopies and measured from the ground and above the atmosphere. The approach for optical scattering from plant canopies will involve studies at three scales: laboratory, field and aerospace. In the laboratory, with conditions for plant growth during various growth regimes carefully monitored, the optical leaf scattering properties of plant canopies will be measured with specific attention to moisture stressed leaves. The field and aerospace investigations will build upon the laboratory results and document the scattering properties of various plant canopies.

W88-70521 **677-24-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
JPL REMOTE SENSING SCIENCE PROGRAM
D. L. Evans 818-354-2418

The goal of the Remote Sensing Program is to develop basic knowledge of electromagnetic radiation interactions with terrestrial materials for the purpose of deriving or inferring land phenomena from satellite acquired remotely sensed observations. This RTOP covers research designed to: (1) develop and validate theoretical models of EM/land interactions; (2) develop methods to separate the atmospheric and surface components of remotely sensed measurements; (3) identify and specify land biophysical parameters which may be derived or inferred from remotely sensed observations and develop methods which may be used for this purpose; and (4) incorporate this knowledge in discipline-specific studies through communication and collaboration with other Land Processes investigators.

W88-70522 **677-27-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GEOPHYSICAL PROCESSING OF SAR IMAGES
M. Kobrick 818-354-4631

One of the primary difficulties in the geoscientific application of synthetic aperture or real aperture radar images is presented by their inherent geometric distortions due to both the imaging technique and the presence of topographic relief. The effect is especially apparent when the images are to be combined digitally with data from other remote sensors such as Multispectral Scanner Subsystem (MSS) or Thematic Mapper (TM), which have quite different imaging geometries. As a result, for many users such registrations have been limited to terrain with little or no relief, a rather severe constraint. With the increasing availability of digital topographic data generated by the Defense Mapping Agency, U.S. Geological Survey and other agencies such registration problems can be considerably alleviated. In addition, having rectified, orthogonalized radar images registered to topography creates the opportunity for a number of other types of analysis, such as radar image simulation, perspective scene generation, and the empirical determination of backscatter curves for homogeneous areas from single images. All that is required for such manipulations is the proper software. Unfortunately, common image processing systems such as VICAR are ill suited to such operations, and can be applied only after kludging the algorithms to account for the radar geometry. No commonly available system specifically addresses or has been developed for the manipulation of radar images.

W88-70523 **677-41-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTISPECTRAL ANALYSIS OF SEDIMENTARY BASINS
H. R. Lang 818-354-3440

The primary objectives are to: (1) evaluate the combined

utility of remote sensing surveys conducted at visible, infrared, and microwave wavelengths for mapping variations in strata, defining stratigraphic sequences and modeling facies, and delineating geologic structures and inferring tectonic regimes at both local and regional scales in the Wind River/Bighorn Basin, Wyoming; (2) compare the types of lithologic and structural information that can be extracted from remotely sensed data with that obtained with conventional field mapping, borehole and geophysical techniques; and (3) develop strategy for integration of geological, topographic, remote sensing, geophysical and borehole data for quantitative basin modeling. The approach is to perform the following as a collaborative effort by geologists from Geology, Radar Science, and Cartographic Groups at JPL, University of Wyoming, and Carnegie Museum of Natural History: acquire and coregister remote sensing data from orbital and airborne systems and conventional data to define stratigraphic units and map facies and determine their physical and mineralogical attributes in order to infer environments of deposition and paleogeographic evolution and map structure in order to infer tectonic evolution. Field and laboratory studies of geological, spectral and botanical conditions will be performed to support analysis and interpretation of remote sensing and conventional data. In FY88, we will consider organizing a workshop to include individuals with expertise in basin analysis and modeling and individuals with detailed knowledge of the stratigraphy and structure of the study area. The workshop will provide an opportunity to identify critical gaps in current understanding of basin evolution and topical geological problems in the study area, and assess utility of geological information derived from remote sensing for addressing these problems. Workshop results will refine the experimental plan for subsequent fiscal years.

W88-70524 **677-41-07**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

REMOTE SENSING OBSERVATIONS OF GEOMORPHIC INDICATORS OF PAST CLIMATE

T. G. Farr 818-354-9057

The objectives are to: (1) determine the extended spectral signatures of desert piedmont surfaces of different ages using multisensor remote sensing data in areas where these surfaces have been dated; (2) determine the effects of surficial modification processes on extended spectral signatures in areas where the types, rates, and magnitudes of modification processes and their changes with time have been determined; (3) use this information to correlate and map the distribution and ages of geomorphic indicators of climate change on desert piedmont surfaces over the southwest U.S.; (4) develop a regional chronology of climate change based on the maps and ages; and (5) evaluate the feasibility of using the extended spectral signatures developed in the southwest U.S. to better understand the Quaternary climatic and neotectonic history of northwestern China. The first year of this three-year study will concentrate on the development of extended spectral signatures of dated type-surfaces at several sites and an evaluation of how surficial modification processes affect these signatures. Sites will include Death Valley, Owens Valley, and Cima volcanic field, Chicago Valley, and Vidal Valley, California; Kyle Canyon, Spring Valley, and Yucca Valley, Nevada; and others, as field data become available. The second year will concentrate on the use of the signatures to correlate and map geomorphic surfaces throughout the southwest U.S. Detailed comparisons will be made between our maps of past land conditions and those derived by others with General Circulation Model (GCM). A workshop on mesoscale models of southwestern paleoclimates and the role of remote sensing will also be convened in the second year. In the third year, we will attempt to extend the results of the first two years to the Altyn Tagh fault zone of northwestern China. This proposal covers the continuation of a basic research effort at JPL on Rock Weathering in Arid Regions. It represents the efforts of one researcher in the Radar Science Group and graduate students at the University of Southern California and Kent State University.

W88-70525 **677-41-22**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

REMOTE SENSING INVESTIGATION OF NEOTECTONIC FEATURES ACROSS QUATERNARY ALLUVIATED SURFACES IN THE MOJAVE AND COLORADO DESERTS OF SOUTHERN CALIFORNIA

J. P. Ford 818-354-6735

We will identify and map neotectonic structures in the alluviated areas of the Mojave and Colorado Deserts of California using remote sensing as the principal tool. Geologic interpretation of high-resolution multisensor multidate spaceborne images supported by field studies forms the basis of this study. Seasat Synthetic Aperture Radar (SAR) and Landsat Thematic Mapper (TM) image data will be assembled and selectively enhanced by digital processing routines to optimize the depiction of surface features. Image observations will be contrasted with seismic and digital terrain data sets. The regional distribution of neotectonic features will be related to known tectonic patterns. We anticipate an improved understanding of the neotectonic fault distribution in the alluviated areas which will provide new geologic input for the refinement of geophysically derived plate boundary models.

W88-70526 **677-41-29**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

MULTISPECTRAL ANALYSIS OF ULTRAMAFIC TERRAINS

M. J. Abrams 818-354-0937

Ophiolites are the on land occurrences of oceanic crust, obducted onto the continents during collision or caught up in suture zones marking the loci of paleo-oceans. They provide the only opportunity to study directly the processes of oceanic crust formation, emplacement, and metamorphism; and they provide indicators of past tectonic assembly of continental fragments. The objectives are to use a combination of remote sensing data, field work, and laboratory analyses to address geologic problems related to crustal evolution. In the Semail ophiolite in Oman, Thematic Mapper (TM) data will be used to: (1) identify sea-floor faults, emplacement faults, and post-emplacement structures to understand the deformational processes involved in oceanic crust obduction; (2) merge topographic data with TM data to map the 3-D configuration of the Moho to refine seismic interpretations of oceanic crust measurements; and (3) separate sub-units of the cumulate gabbro sequence to characterize rift magma chamber geometry and processes. In Tibet Thematic Mapper and Speed Position and Track (SPOT) data will be used with field work and dating to determine the tectonic history of the Karakoram fault, one of the major tectonic features related to the collision of India with Asia; and the history of the Bangong-Nujiang suture zone, the site of a Jurassic ocean closure which was reactivated as a strike-slip fault during Indian-Asian collision. In Wyoming TM and Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) data will be used to characterize an Archean ophiolite in a greenstone belt, and compare spectral and structural characteristics of the assemblage with the Cretaceous Oman ophiolite to develop a model which will allow other Archean and Proterozoic ophiolites to be identified.

W88-70527 **677-42-00**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

MEASUREMENT OF ROCK AND SOIL SPECTRAL FEATURES ACROSS VEGETATION DENSITY GRADIENTS

C. D. Elvidge 818-354-2315

The goal of the proposed research is to develop and evaluate techniques for removing the influence of green vegetation from the analysis of rock and soil spectral features in Thematic Mapper (TM) and Thermal Infrared Multispectral Scanner (TIMS) data. Vegetation densities as low as 30 percent cover are able to obscure significant rock and soil spectral features when conventional data analysis procedures are used. This proposal is directed towards retrieving and enhancing the rock and soil spectral component present in TM and TIMS data of areas having discontinuous plant canopies. There are two primary steps involved in the removal of the green vegetation component from TM data. First, the digital number contribution of green vegetation will create a residual TM

data set in which the rock and soil spectral components are concentrated. Second, the intensity of the residual TM data will be multiplied by the fraction of exposed rock and soil, which is also estimated with a vegetation index. This area correction is performed to compensate for the changes in the quantity of rock and soil exposed across vegetation density gradients. Rock and soil spectral features in TIMS data are measured as departures from the blackbody condition. Because vegetation is essentially a blackbody emitter, it is not necessary to subtract the vegetation DN contribution from TIMS data. What is required is an area correction. The TIMS data will be registered to NS001 Thematic Mapper Simulator (TMS) data in order to have access to a TM band vegetation index. A decorrelation stretch will be applied to the TIMS data. The intensity of the decorrelated TIMS data will be multiplied by the fraction of exposed rock and soil, which is estimated with the vegetation index. Field checking of the results will be conducted with the assistance of geologists familiar with the study areas.

W88-70528 **677-43-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EVOLUTION OF VOLCANIC TERRAINS
A. B. Kahle 818-354-7265
(677-80-23; 677-43-25)

This RTOP covers a transition from a remote sensing project to a geologic project. The long range goals of this project are two-fold: (1) to study the historic and prehistoric eruption histories of a number of volcanic centers, particularly changes in volumes, rates and chemistry; and (2) to develop and evaluate the use of weathering histories of lava flows to infer paleoclimatic conditions. The specific objectives this year are: (1) map selected historic and prehistoric flows on Hawaii, in collaboration with personnel from the USGS HVO (Lockwood); (2) study very young flows on Hawaii (1984 Mauna Loa, 1985 Puu'Oo) to determine degree of separability of units based on initial states, using remote sensing techniques, and to determine the very early weathering changing; (3) quantify weathering characteristics for a number of dated flows of varying compositions in different climatic settings in Hawaii, Italy, and the Western U.S. as determined by remote sensing; and (4) bring together volcanologists in a workshop to explore the utility of remote sensing as applied to problems of volcanic history and subaerial crustal growth through volcanism. We anticipate significant progress in the understanding of the applicability of remotely sensed data to problems in volcanology. We will make contributions to improved mapping of flows in Hawaii. We will develop weathering trajectories for Hawaiian basalts as a function of initial state and climatic zone, and will begin monitoring of changes in flows of 1984-present. We will have preliminary weathering trajectories for other volcanic types and environments in Italy and the Western U.S., and should know if the results we perceive in Hawaii will be achievable in these other areas. Preliminary findings on the nature of climatic effects on the weathering state of volcanic rocks in the Western U.S. should be in hand to guide us in the continuation of that effort. Our workshop will further the use of remote sensing in the solution of problems in crustal growth through volcanic processes.

W88-70529 **677-43-21**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TECTONICS OF WESTERN BASIN AND RANGE
R. G. Blom 818-354-4681

The objectives of this study are to develop and evaluate the capability of mapping detachment faults from remote sensing data, apply this first in an accessible region which is the subject of much study at present, and extend the capability for efficiently mapping such structures elsewhere. Recent study of detachment faults in the southwestern U.S. reveals major Tertiary crustal extension, in part on reactivated Mesozoic thrusts. This type of extensional tectonics may be a previously unrecognized major phase of continental margin tectonics. These faults expose basement deformed in a ductile manner in low-angle fault contact with upper plate rocks deformed in a brittle manner. A consortium, similar to COCORP, of geological investigators called CALCRUST has been formed and funded by NSF at $1.4M to begin seismic study of selected detachment faults. It is likely that many detachment faults, even in the southwest, have yet to be recognized. Despite the tremendous amount of work done in the southwest, the major tectonic problems remain elusive. This remote sensing study is thus a logical and timely complement to the CALCRUST study. The essence of the study is acquisition and study of Landsat Thematic Mapper (TM), Seasat, SIR-A-B (Spaceborne Imaging Radars), and Large Format Camera (LFC) images, initially for CALCRUST targets and then to surrounding areas. The spectral and morphotectonic characteristics of detachment faults discernible in the images will be documented, beginning with known faults, moving to faults in crystalline rocks, and then integrating a regional picture. Research emphasis is on fault detection, determination of structural levels involved, and regional synthesis. Cooperation with UCSB and CALCRUST investigators is planned. The goal is development of a remote mapping strategy for these features.

W88-70530 **677-43-23**
Goddard Space Flight Center, Greenbelt, Md.
CONTINENTAL ACCRETION
Nicholas M. Short 301-286-7870

This RTOP continues and expands studies relating structure and other internal characteristics of accreted terranes to morphotectonic and other geomorphic aspects of these terranes as expressed topographically (as terrains). Three scientific objectives guide the research: (1) refine conventional procedures used in quantitative geomorphology to analyze terrains as displayed in space imagery and related digital data; (2) define the surface expression of terranes as a possible indicator of structural fabric and boundary characteristics that may afford clues to mode(s) of multiterrane emplacement; and (3) integrate terrain-terrane analysis results with models for continental growth. Digital image analysis techniques will be adapted to accomplish some of the objectives. Measurements of maximum elevation, relief, distribution of hillslope steepness and aspect, drainage net geometry, (ridge) divide density and orientation will be carried out on topographic maps, digital topographic data, and space imagery (Landsat, Seasat, Speed Position and Track) at scales ranging from local to regional. After finishing a current study of the geomorphology of accreted terranes in the Oregon Klamath Mountains, similar studies will be undertaken in the California Klamaths and on classic terranes in British Columbia. Studies so far suggest that individual terranes in an assemblage differ in elevation, slope steepness, and divide orientation. These preliminary results will be tested at two more test regions and, if confirmed, should lead to further insight into modes of emplacement and subsequent tectonic and erosional histories of terranes as components of continents that may experience much of their growth by accretion.

W88-70531 **677-43-24**
Goddard Space Flight Center, Greenbelt, Md.
TOPOGRAPHIC PROFILE ANALYSIS
James B. Garvin 301-286-6565

This project will quantitatively analyze high-resolution topographic profiles obtained from aircraft laser altimetry, as well as from oceanographic radar altimetry data overland (e.g., GEOS, Seasat, and Geosat) in order to explore and define fundamental wavelengths associated with dynamic surface processes such as volcanism, tectonism, impact, and erosion. Heretofore unavailable topographic data will be acquired, processed, and interpreted by means of a GSFC aircraft laser altimeter (20-10 m footprints, approximately 1 m vertical precision) and, will, for the first time, permit exploration of the spectral topographic (and slope) properties of erosion, catastrophic phenomena, and geodynamic processes (crustal warping, etc.) Data has been or will be obtained from the GSFC aircraft laser altimeter (developed by J. Bufton of Code 674 and colleagues) for selected targets including youthful volcanics (SP flow/cone, Surtsey, Heimaey in Iceland, and Snake River Plain flows), coastal erosion features (Delmarva Barrier Island dunes), paleo beach terraces (L. Bonnevile, Utah) and high resolution spatial and vertical topographic profiles will subsequently

be analyzed by means of classic spectral analysis and interpreted. Dominant wavelengths associated with specific terrains and processes will thus be defined. Such data can then be used as boundary conditions in mechanical models for certain landforms. In order to explore longer wavelength properties of crustal structure associated with major tectonic belts on the earth, GEOS and Seasat altimetry retracked over land targets in the Tibetan Plateau and Chad Basin will be analyzed by means of isostatic and flexural models.

W88-70532 **677-43-25**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REMOTE SENSING OF VOLCANIC FEATURES
D. C. Pieri 818-354-6299
(677-80-23)

Under this RTOP we hope to acquire and analyze multispectral data on active and emplaced volcanic features with attention to the thermal infrared (e.g., Thermal Infrared Multispectral Scanner or TIMS, Inframetrics 525). In particular, we will investigate the relationship between remote data (e.g., TIMS, Airborne Imaging Spectrometer or AIS, Zeiss, radar) and the spectral-physical characteristics and processes of active and emplaced volcanics (e.g., composition, surface texture, formation parameters). Underway currently is a morphology process model spectral comparison of Hawaiian and Italian volcanic shields, as well as thermal analysis of high-risk calderas in California, New Mexico, and Italy. We are drawing on data and techniques already acquired and proven by the JPL Geology Group, plus ongoing work in theoretical and applied volcanology by the author and other JPL co-workers. Ultimately, we hope to utilize these techniques from earth orbit to address basic volcanological problems, as well as global habitability and societal risk concerns, particularly with regard to high-energy explosive volcanic events.

W88-70533 **677-43-25**
Goddard Space Flight Center, Greenbelt, Md.
EAST AFRICAN RIFT TECTONICS AND VOLCANICS
James R. Heirtzler 301-286-5213

The objective of this RTOP may be stated as follows: within the general region of the East African Rift, determine the temporal and spatial distribution of volcanism and the relationship of volcanism to tectonics, as well as study crustal magnetization and thermal structure. This project will focus on the use of remotely sensed data in order to study and characterize the region as a whole. However, existing ground based data, and published reports will also be included. Appropriate data sets include Landsat Multispectral Scanner Subsystem (MSS) and Thematic Mapper (TM), Advanced Very High Resolution Radiometer (AVHRR), Speed Position and Track (SPOT), Large Format Camera, Spaceborne Imaging Radar B (SIR-B), and Magsat, as well as geologic, tectonic and aeromagnetic maps.

W88-70534 **677-43-26**
National Space Technology Labs., Bay Saint Louis, Miss.
DELTAIC EVOLUTION (COLD FRONTS AND GEOMORPHIC EVOLUTION)
O. K. Huh 504-388-2952

Three study areas, representing different evolutionary stages in a muddy delta coast have been selected: (1) a retreating, sediment starved coast, (2) a prograding, sediment rich coast, and (3) a transitional coast. After base line surveys, physical processes and suspended sediment will be monitored via remote sensing and field data collection, through multiple cold front passages to establish process-form links. With these data, quantitative measures of geomorphic/sedimentologic responses (sediment transport, erosion, and accretion) will be made. Although funding arrived late in the year, progress has been sustained. Flight lines and geographic reference points for aircraft missions along the Louisiana Chandeleur Island Arc, Atchafalaya Delta, and Chenier Plain coasts have been selected, flown twice, and critiqued. Mission 1. Low altitude (6600 ft.) and high altitude (39,000 ft.) passes over the Louisiana coast in Feb. 1986, acquiring CAMS imagery and False color IR photography. Mission 2. Low altitude (6600 ft.) passes over the Louisiana coastal flight lines conducted March 25, 1987, with ground party providing surveyed georeference points and surface temperature, turbidity, and radiosonde atmospheric profile measurements. Offshore Meteorological and Oceanographic Data constructed a schematic diagram postulating the relationships between atmospheric forcing, oceanic reaction and resulting geological responses. A five-year offshore meteorological and oceanographic data set has been acquired and archived. These data consist of hourly measurements of atmospheric pressure, air temperature, wind speed, and direction, wind gusts, significant wave height and period, and water levels. These measurements were made from 5 Conoco oil rigs in the N.W. Gulf of Mexico from 1982 through the present. Computer programs were written to analyze water levels recorded at the offshore platforms. They were tested using a one year record at two stations.

W88-70535 **677-43-27**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
APPLICATION OF REMOTE SENSING IMAGERY TO TECTONIC PROBLEMS IN NORTHEAST AFRICA AND THE RED SEA REGION
T. H. Dixon 818-354-4977

The objectives of this RTOP are to: (1) understand processes and rates of late Precambrian continental evolution and growth in Northeast Africa-Arabia; (2) understand development and evolution of Tertiary to Recent Red Sea rift in context of a propagating rift model in heterogeneous lithosphere; and (3) evaluate utility of various remote sensing data sets in the region for attacking the above problems. The approach will be to generate regional image mosaics; obtain, process and interpret detailed remote sensing images in key areas; perform field mapping and ground verification studies in selected areas; and generate quantitative models constrained by above data.

W88-70536 **677-43-27**
Goddard Space Flight Center, Greenbelt, Md.
A GEOBOTANICAL, GEOLOGICAL, GEOPHYSICAL INVESTIGATION OF AN ARCHEAN SUBPROVINCE BOUNDARY (QUETICO/WABIGOON) USING REMOTELY SENSED DATA
Robin Bell 301-286-3621

The objective of this RTOP is to determine whether evidence supports the theory that the Quetico/Wabigoon subprovince boundary, within the Canadian Superior (Archean) Province marks a major tectonostratigraphic boundary. The hypothesis is that the subprovince boundary marks an ancient suture zone, implying that modern plate tectonics theory is applicable to the older-pre-paleozoic geodynamics regime. Secondary objectives include documenting the relationships between forest assemblages, soil and rock type and spectral signatures in Boreal ecosystems; assessing synergism (if any) effected through the integration of disciplines; and developing an understanding of the usefulness of various techniques in a regional tectonic investigation. Ground truth in the form of field work and existing maps will be used to refine knowledge of lithologic distribution. Remote sensing derived maps will then be generated to guide further field work with respect to geochemical sampling and vegetation surveys. Visible, IR, radar and geophysical data will be applied to the interpretation of the lineament patterns and thus, stress regime. Geophysical data will be used to interpret deep crustal geometry across the subprovince boundary. Geochemical data will constrain geophysical models. A model of tectonic origin will be developed, further constrained by paleomagnetic data. Hypothesis of boundary = suture will be re-examined in light of data analyses.

W88-70537 **677-45-03**
Goddard Space Flight Center, Greenbelt, Md.
SOURCES OF MAGNETIC ANOMALY FIELD
Patrick T. Taylor 301-286-5412

The objectives of this RTOP are to study the short wavelength magnetic anomaly field recorded at satellite altitude, to interpret these data in terms of crustal geology and tectonics, and to develop and improve anomaly reduction and analysis methods for use with

the Magsat data and future near-earth magnetometer missions (e.g., Geopotential Research Mission or Tether). Using the methods and techniques previously developed to reduce and interpret Magsat data we are computing anomaly maps for significant geologic and tectonic regions. These data are interpreted with reference to the geometry and the contrasting magnetization. Geologic inferences or interpretations are made from the parameters which produce the most plausible match with the observed field. Higher order interpretation methods permit us to make inferences as to the character and mode of magnetization; that is we determine if remanent magnetization is important or if the means of magnetization is induced or thermoremanence magnetization (TRM) or viscous remanence magnetization (VRM). Petrologic character is used to determine possible source-rock types. This RTOP represents an integrated interpretation approach to the study of Magsat data.

W88-70538 **677-45-06**
Goddard Space Flight Center, Greenbelt, Md.
DETERMINATION AND INVERSION OF CRUSTAL MAGNETIC FIELDS
Robert A. Langel 301-286-6603

The basic objective of the program is to isolate crustal fields from the core and external fields and to invert the isolated crustal fields to an equivalent crustal magnetization. Products include filtered data, average anomaly maps, reduced (to common altitude, to the pole) anomaly maps and magnetization maps. Both the digital data and the actual map are included. The consequences of failure to isolate the crustal fields perfectly are investigated. The approach consists of: (1) the development of suitable data selection criteria; (2) the development and testing of appropriate filters; (3) evaluating models of the core field; (4) estimating or modeling external fields and correcting the data suitably; (5) theoretical analysis of inversion techniques and implementation of useful results; and (6) devising forward models to simulate expected anomaly behavior for evaluation of both the validity of solution of crustal fields and consequences of errors in that isolation.

W88-70539 **677-45-09**
Goddard Space Flight Center, Greenbelt, Md.
MAGNETIC PROPERTIES OF CRUSTAL MATERIALS
Peter J. Wasilewski 301-286-8317

Satellite magnetic anomalies provide a unique global perspective for the distribution of magnetization contrast in the magnetic lithosphere. It can be argued that this distribution magnetization contrast must be explained in terms of a global geologic context. The principle goal of research under this RTOP is to define the framework of the global geologic context and study carefully selected samples which will help explain the geological basis for magnetization contrast. Critical to the realization of our objectives is the sampling of specific lithologic associations that can provide, after laboratory study, some intelligent assessment of magnetic mineral characteristics (including size, composition, microstructure, and amount) associated with lithogenesis and various metamorphic modifications. The sampling must account for: igneous rock genesis and distribution, lithogenesis associated with specific geodynamic scenarios, prograde and retrograde metamorphism, and crustal segment juxtaposition. The product of the laboratory research will be crustal models depicting the lateral variation of the vertical distribution of magnetization. Additionally we will explore the potential of integrating other remote sensing techniques (initially with laboratory spectra at 0.4 to 2.4 m and magnetic properties) with airborne magnetic anomaly data.

W88-70540 **677-46-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CHARACTERIZATION OF GEOLOGIC SURFACES USING MULTIPARAMETER AND INTERFEROMETRIC RADAR DATA
D. L. Evans 818-354-2418

The ability to characterize the physical nature of the earth's surface and cover is fundamental to many Earth Science investigations. For example, the Committee on Earth Sciences of the National Research Council Space Science Board recommended that one of the key objectives for Earth Science from Space should be to determine the global distribution of continental rocks. Any initiative of this kind requires large scale mapping of both composition and morphology. While many sensors have become available in the past decade that make this sort of mapping possible, data analysis and interpretation tools have not been developed to the extent required to meet this objective. Specifically, while the role of radar in geologic remote sensing has been outlined in several documents, the detailed strategy for using Synthetic Aperture Radar (SAR) data in geologic process studies is not well-established. In addition, while the importance of high resolution land surface topography (up to 10 cm height 30 m horizontal resolution accuracy) for geologic mapping has been stressed by several NASA planning committees, methods for acquisition and reduction of this data in a routine manner need to be developed. The goal of this proposed research is to establish a quantitative link between geologic parameters and information derived from multiparameter SAR measurements. The specific objectives of the proposed research are: (1) to develop quantitative methods to extract and interpret geologic characteristics such as surface roughness and geometry, subsurface conditions, and vegetation density from multiparameter radar images; (2) to develop and implement data analysis tools for interpretation of SAR data alone and in conjunction with data acquired with other sensors using transportable workstation software that can be distributed to other investigators analyzing airborne and spaceborne SAR data; and (3) to develop tools for derivation and analysis of high resolution (1m) topographic and topographic change (1 cm) information using radar interferometry data from both airborne and spaceborne platforms.

W88-70541 **677-80-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THERMAL INFRARED IMAGING SPECTROMETER
A. Kahle 818-354-7265
(677-80-23)

The objective is to modify the existing JPL Airborne Imaging Spectrometer (AIS) 2 to be a thermal infrared imaging spectrometer (TIIS). We propose two modules to allow calibrated high spectral resolution, narrow-field-of-view image data acquisition in the 8 to 12 micrometer spectral region (module 1 or TIIS 1) and the 3 to 5 um region (module 2, TIIS 2). This RTOP is for TIIS 1 only and a follow on RTOP for TIIS 2 will be submitted after TIIS 1 has proved the concept. The plan is to fly this instrument with the TIMS (Thermal Infrared Multispectral Scanner). TIMS, with six thermal channels and a 78 deg total field of view, will provide a synoptic overview of a scene, and the TIIS will provide identification of surface units mapped by TIMS. The new instrument (TIIS 1) will be designed such that a simple exchange of plug-in electronic parts and the exchange of optical input assemblies will be required to convert from TIIS 1 to AIS 2 and back. The exchange process is expected to take one or two days at the most. Elements of this effort include optical and mechanical design, fabrication and assembly, a new cooling system, minor electronic changes, calibration, system integration and testing, and flight testing. (Funding for calibration equipment is being requested from internal JPL funds.) The AIS 2 instrument will not be required for modification until 5 months after the initial design activities have started. At that point the instrument will not be available for AIS 2 activities until the completion of TIIS modifications (10 weeks).

W88-70542 **677-80-19**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LAND PROCESSES PROGRAM SUPPORT
C. Elachi 818-354-5673

The objective of this RTOP is to provide support to the Land Processes Branch, Earth Science and Applications Division, by the assignment of JPL detailees to NASA Headquarters. The primary duties of the detailees will be to provide assistance in the development and monitoring of the NASA Land Processes programs.

C-2

W88-70543 **677-80-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IMAGE PROCESSING CAPABILITY UPGRADE
S. D. Schultz 818-354-8009

The objective of this work is to upgrade the facilities available to the geology group for both image processing and X-ray analysis of samples. The current operational image processing computer system consists of the group's VAX 11/750 computer, 1.2 gigabytes of disk storage, 1 tri-density high speed tape drive, 1 medium density tape drive, an interactive color image processing workstation, a Sun workstation configured as an Airborne Imaging Spectrometer (AIS) data analysis workstation, as well as the TAE-VICAR2 and DIPIX image analysis software package. Both the VAX 11/750 and the Sun workstation are on a network which also includes the Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) VAX and AVIRIS Sun workstation. The current X-ray diffraction system is not in compliance with radiation safety standards. Upgrades to the geology group's facilities that are required this year include replacement of the unsafe X-ray unit with an Automated X-ray diffractometer interfaced to a microcomputer, additional disk storage and as maintenance services for the group's VAX computer. The approach to be taken in this project consists of two tasks: the purchase of a new X-ray diffractometer, generator, microcomputer and analytical software that will both automate the X-ray analysis task and bring the operation up to radiation safety standards; and is the purchase of maintenance services and additional disk space for the geology group's VAX computer.

W88-70544 **677-80-23**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TIMS OPERATIONS
A. B. Kahle 818-354-7265

The main objectives of the proposed research are: (1) to develop, implement and test new algorithms for the Thermal Infrared Multispectral Scanner (TIMS) data analysis; (2) to maintain the current level of support of the TIMS user community including aid in use of TIMS data and laboratory and spectroscopic support; (3) to encourage more widespread use of TIMS data and expand collaboration with researchers who are using TIMS data; and (4) to continue calibration and documentation of the TIMS instrument. In the first year, we will refine methods to derive quantitative physical units from the TIMS data. The objective is to produce accurate surface radiance images on a routine basis. In the second and third years we will make detailed comparisons of image results with data from laboratory and field instruments. We will also begin working on algorithms integrating TIMS data with those acquired by the prospective TIIS (Thermal Infrared Imaging Spectrometer) instrument and other higher resolution thermal infrared scanners, and determine how to best utilize these data sets. Our approach for derivation of accurate surface radiance determinations will involve the refinement of current atmospheric models, and observations of how the TIMS data that have been reduced to units of temperature and emissivity change due to instrumental factors. Topographic information will be integrated into the model. Other approaches to the solution of the atmospheric corrections will be implemented and compared to the base model results, including methods utilizing natural blackbodies such as heavy vegetation and standing water bodies. With the accurate surface radiance values we will examine, in detail, different ways of separating the effects of emissivity from the effects of temperature. In this effort we will use coregistered day/night image pairs, and scenes that have a single geologic unit at two distinct temperatures. Participating in the research will be scientists at the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia. Present level of support to other TIMS users will be maintained.

W88-70545 **677-80-25**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IMAGING SPECTROMETER OPERATIONS
G. Vane 818-354-2851

The general objective of this RTOP is to routinely collect, process and distribute calibrated Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) data for two dozen NASA investigators conducting research in earth remote sensing. The spectral region of interest is the 0.41 to 2.45 micrometer region, sampled at approximately 10 nm spectral sampling interval. The specific objectives covered by the four tasks under this RTOP include: overall coordination of AVIRIS operations; maintenance of the AVIRIS instrument; complete spectral, radiometric and geometric calibration of the AVIRIS system; routine performance evaluation of the system; archival and retrieval processing of the equivalent of 10 full high density flight tapes; timely distribution of data products to investigators; support to investigators visiting JPL to use the AVIRIS computer facility for data analysis; and further upgrades to the Spectral Analysis Manager (SPAM) software to incorporate new algorithms designed specifically for the extraction of information from AVIRIS data from vegetated test sites. The approach to meeting these objectives is based on utilizing the expertise of a selected number of key individuals who were instrumental in the development of the AVIRIS system. The operations team consists of the AVIRIS instrument and data system engineers and key members of their staffs. The calibration lab includes the equipment and facilities purchased or developed under system development funding, and SPAM upgrade will be done under the chief architect of the original software.

W88-70546 **677-80-28**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AIRCRAFT SAR REBUILD, CALIBRATION AND OPERATIONS
D. Held 818-354-7763

This RTOP provides the FY88 funding required to: (1) complete the construction and testing of the JPL L- and C-band Synthetic Aperture Radars; (2) install those instruments on the NASA DC-8 during the period from October 1987 through January 1988; (3) conduct an experiment in support of the calibration of at least the L-band portion of that instrument in February 1988; and (4) provide the manpower and materials to conduct a total of 21 flights in support of NASA-approved investigators, staged in two deployments between February and September 1988. By the end of FY87, the L- and C-band radar will be completed and lab-tested at JPL. It is then necessary to install the equipment on the new DC-8 and to flight test that equipment. This RTOP includes a baseline Airborne SAR Rebuild T-43 to cover this activity. In addition, we have included three additional T-43's (Cross-Track Interferometer, Airborne SAR Augmentation, and Wide Band SAR Development), over the Guidelines, to highlight additional tasks, over-and-above the baseline which we feel should receive near-term consideration for funding. The SAR Calibration T-43 addresses a task to be performed immediately after installation and engineering flights have been completed. The experiment is focused on the L-band instrument, but also provides verification of the C-band instrument. The Aircraft SAR Operations T-43 covers both fixed and marginal costs for the conduct of 21 flights in support of NASA-approved investigators. It has been assumed that the first set of flights will immediately follow the rebuild and calibration of the SAR. It is further assumed that the radar will then be dismantled and subsequently re-installed on the DC-8 for the second set of flights.

W88-70547 **677-80-28**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LAND PROCESSES ADVANCED STUDIES
C. Elachi 818-354-5673

The objective of this task is to support the NASA Land Processes Branch in the development and scientific use of remote sensing techniques to study land processes phenomena as they shape our biologic and geologic environment. The approach will consist of three aspects: (1) invite distinguished scientists in the field to spend some time (a few weeks to a few months) at JPL to work with JPL scientists; (2) support new ideas and approaches to the level of allowing the submission of viable proposals for peer review, and (3) organize symposia on Advances in Earth Observation from Space.

W88-70548 **677-80-28**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TOPOGRAPHIC MAPPING WITH A SCANNING RADAR ALTIMETER
T. H. Dixon 818-354-4977

Worldwide digital topographic data for the continents and ice sheets is obtainable with a narrow beam scanning radar altimeter. We propose to continue evaluation of the science needs and potential technological approaches for such a mission, considering both Earth Observing System (EOS) and free-flyer platforms. The main science evaluation phase involved formation of a science working group, in FY86 and FY87, composed of potential users of topographic data. These included representatives of the geological and geophysical sciences, polar sciences, and botanical and ecosystem sciences. Their findings have been incorporated into a specific set of mission requirements, published in FY87. We now propose critical follow-on studies based on this preliminary assessment. Some of the key scientific questions requiring further studies include: (1) statistical description, analysis of actual topography data and their variations with terrain type; (2) evaluation of the effects of penetration through vegetation cover in high resolution altimeter; and (3) the potential of extracting useful vegetation density using the altimeter signals. One key scientific question identified involves for land surfaces that have rougher/slope changes substantially larger than the intrinsic radar range resolution, the meaning of the height retrieved from the signal and its relationship to mean pixel height, scattering characteristics at the radar frequency of interest (35GHz), etc. It is also important to continue small-scale studies of key technology items required. A key example is the scanning criteria design. Key technology items that now need to be addressed include antenna design, e.g., the use of phased array for beam steering, folding versus non-folding designs and the effects of each of these on spatial and height resolution, as well as cost. Key science areas requiring further study include a statistical description of real topography (and variation with terrain type) and measurement of backscatter at higher (e.g., 37GHz) microwave frequencies.

W88-70549 **677-80-80**
Goddard Space Flight Center, Greenbelt, Md.
PROGRAM DEVELOPMENT (GSFC)
Vincent V. Salomonson 301-286-6481
(677-24-01; 677-22-27; 676-59-32)

The overall purpose of this collection of investigations is to advance some high potential or key areas of effort in such a way as to amplify or strengthen the total Land Processes Program at Goddard and in NASA. The areas to be amplified or strengthened include: (1) the use of the aperture synthesis concept for long wavelength, passive microwave radiometry; (2) the applications of areas of effort; (3) support of the NASA Headquarters Hydrology Program/meetings; (4) improvement of laser altimeter transmitters, receiver electronics and associated aircraft platform dynamics; (5) implementation of the Advanced Solid-State Array Spectrometer for Earth Observing System (EOS) simulation purposes; (6) support of NASA Headquarters Terrestrial Ecosystem Program Activities; (7) support of NASA Headquarters Program Activities; (8) operations and management of Computer Facilities; and (9) characterization of Thematic Mapper performance and other optical sensors. The principal results expected in the next year are airborne testing of the L-band aperture synthesis concept and installation of a First ISLSCP Field Experiment (FIFE) and IRAP Geographic Information System (GIS). The special data base for sedimentary basins will be expanded and operations supported. Parts will be procured and modifications made to Nd:Yag laser system with 1-5 n sec pulses with high peak power. The Advanced Solid-State Array Spectroradiometer (ASAS) will be installed on NASA's DC-8 with support equipment to process high volumes of data. Other activities include continuing analyses of the data and general support for Headquarters programmatic functions.

W88-70550 **677-92-00**
Goddard Space Flight Center, Greenbelt, Md.
IDS LAND CLIMATOLOGY PROGRAM
Harold Oseroff 301-286-9538

The Interdisciplinary Science Land Climatology Program is conducted to investigate long-term coupled physical, chemical, and biological changes in the earth's environment on a global scale (atmosphere, land, and oceans). Such research is intended to develop an increased understanding of processes which can only come through the integration of scientific results which are obtained from discipline-specific earth sciences research activities. GSFC responsibility includes the project management and several of the fundamental research tasks. Seeking new research and evaluating proposals; monitoring continuing studies; and conducting workshops, progress review meetings and conference technical sessions, as well as performing the necessary procurement activities will be continued in a manner similar to previous years.

W88-70551 **677-92-24**
Goddard Inst. for Space Studies, New York, N.Y.
GLOBAL ANALYSIS OF THE RELATIONSHIP BETWEEN VARIATIONS IN LAND COVER AND VEGETATION INDICES FROM AVHRR
Inez Fung 212-678-5590
(677-92-25)

The objectives of this RTOP are: (1) quantitative evaluation of the natural variance of the normalized difference vegetation indices (NDVI) calculated from Advanced Very High Resolution Radiometer (AVHRR) radiance measurements; (2) investigation of the interannual variations of vegetation dynamics and the feasibility of detecting these variations using the AVHRR NDVI; and (3) development of quantitative relationships between seasonal and longer term variations of the NDVI and climate observables. Previous support on this RTOP has resulted in the systematic classification of vegetation cover using the NDVI. We propose to analyze the multi-year global distributions of the NDVI for the space and time variations of the NDVI within each vegetation type. Effects of atmospheric scattering and absorption and surface angle dependence on the NDVI will be estimated using the International Satellite Cloud Climatology Project (ISCCP) radiance data from which these effects have been removed. Statistical analysis of the relationships between the NDVI's and climate variables will be performed to develop algorithms to predict vegetation indices and vegetation dynamics from climate variables. These climate variables will include surface air temperature and incident solar radiation at the surface from ISCCP data archives.

W88-70552 **677-92-25**
Goddard Inst. for Space Studies, New York, N.Y.
GLOBAL SURFACE ALBEDO AT HIGH RESOLUTION
William B. Rossow 212-678-5567
(677-92-24)

The objective of this RTOP is to derive highly accurate global maps of surface albedo from satellite measurement to serve as a reference for monitoring of surface changes associated with climate variations. In so doing, we will develop methods for accounting for atmospheric effects on the satellite measurements, especially aerosols, and derive models of the angular dependence of surface reflectance as a function of surface type (vegetation cover, land use, geological regime). We will utilize the calibration work already done for the International Satellite Cloud Climatology Project (ISCCP) as well as that associated with the International Satellite Land-Surface Climatology Project (ISLSCP), the First ISCCP Regional Experiment (FIRE), and the First ISLSCP Field Experiment (FIFE), to calibrate channels 1 and 2 on the Advanced Very High Resolution Radiometer (AVHRR). ISCCP cloud analysis results will be refined to obtain global clear sky radiances at 25 km resolution for 12 months. We will use complete radiative transfer models, already developed at GISS, to correct for atmospheric effects. Bi-directional reflectance functions and spectral dependence models will be developed for each surface type using observed variations of the clear sky radiances with geometry and wavelength. The ocean will be used as a reference surface to develop an

aerosol correction to the albedo values. Expected results include definition of the global distribution of surface albedo, for two narrow and the total solar spectral intervals, with sufficient accuracy to serve as the reference distributions for global change monitoring. Two global maps of surface albedo for each month of 1984 and 1988 will be produced from the ISCCP data and will be compared to determine the nature of any global and regional changes.

Advanced Studies--Explorers

W88-70553 **689-13-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ORBITING VERY LONG BASELINE INTERFEROMETRY (OVLBI)/QUASAT
J. F. Jordan 818-354-7790

The objective of this RTOP is to delineate the scientific goals and systems for the space applications of very long base interferometry (VLBI) and provide for assessment studies of and demonstrations of the technologies for future space VLBI missions. A joint NASA-ESA VLBI explorer mission, QUASAT, has been proposed and assessed. ESA has selected QUASAT for a phase A study in FY87 and FY88. NASA has agreed to support the phase A study in some key technical areas including U.S. Deployable Antenna technologies, tracking with the Deep Space Net, and mission operations. JPL will therefore continue to provide scientific and engineering support for the mission definition studies being performed jointly between NASA and ESA. JPL will also continue to provide scientific analysis support for a readiness demonstration of space-VLBI technologies using the Tracking and Data Relay Satellite System (TDRSS).

Crustal Dynamics

W88-70554 **692-30-00**
Goddard Space Flight Center, Greenbelt, Md.
CRUSTAL DYNAMICS
R. J. Coates 301-286-8809

The scientific objectives are to improve the knowledge and understanding of: (1) regional deformation and strain accumulation related to large earthquakes in the plate boundary regions in western North America; (2) contemporary relative motions of the North American, Pacific, South American, Nazca, Eurasian, and Australian Plates; (3) internal deformation of continental and oceanic lithospheric plates, with particular emphasis on North America and the Pacific; (4) rotational dynamics of the earth and their possible correlation with earthquakes, plate motions, and other geophysical phenomena; and (5) regional deformation in other areas of high earthquake activity. In order to achieve these objectives, an extensive measurement program utilizing both very long baseline interferometry (VLBI) and satellite laser ranging (SLR) is underway. Frequent high-accuracy measurements of baselines between many stations in active areas near plate boundaries are being made to determine regional deformation and strain accumulation. Baselines between a global set of stations are being measured repeatedly to determine relative plate motions. Repeated measurements of baselines between several stations on the same plate are being made to determine the internal deformation of the plate. Polar motion and earth rotation variations are derived from daily measurements with a global set of stations in stable locations.

W88-70555 **692-40-40**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STRAIN MODEL
John M. Davidson 818-354-7508

This RTOP is intended to perform an analysis of the current data base of precise positions which have been determined by the space-geodetic techniques of very long base interferometry (VLBI), satellite laser ranging (SLR), and Global Positioning System (GPS) based systems. The primary goal of this analysis is to produce a set of relative site velocities and their associated uncertainties which is based upon all available information concerning the measured positions, their uncertainties, and correlations between them. These velocities will then be used to provide constraints on current kinematic and dynamic models of crustal deformation in regions, such as the Pacific-North America plate boundary in California, where a sufficient data base of precise positions is available. Our analysis of the space-geodetic positions is based upon the formalism of continuum mechanics. A network of sites is used to define spatial regions. The measured changes in the site positions are used to estimate, by a least-squares procedure, the elements of the displacement gradient rate tensor for each of these regions. The elements of this tensor contain all of the information necessary to calculate the relative site velocities for the sites defining each region. The only other estimated parameters in this model are the site positions at a reference epoch and three angles which describe the effects of small perturbations in the orientation of the earth in space.

W88-70556 **692-40-60**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DSN SUPPORT TO MOJAVE BASE STATION OF CDP
Earl B. Jackson 619-386-8325

This RTOP is intended to provide Facility, Logistical, Purchasing, and Depot Level Repair Capability to the Mojave Base Station of the Crustal Dynamics Project (CDP), located at the Goldstone Deep Space Communications Complex (GDSCC). The Deep Space Network (DSN) operated for NASA by JPL, through in-place capability at the Goldstone Deep Space Communications Complex, will provide this needed support to the Mojave Base Station. In particular, Custodial, HVAC, Logistical (parts issue and purchasing), Depot Repair of Modules and Test Equipment, Electrical, Test Equipment Calibration, Water and Electric Power services will be provided by the DSN to the Mojave Base Station of the CDP. Additionally, through an in-place contract with the Government Services Administration (GSA), supplementary vehicles will be provided as needed to meet observation needs. The needed support and method of providing such support is described in more detail in a Memorandum of Agreement between the Director, Ground Networks Division OSTDS and Director, Earth Science and Applications Division OSSA, dated 28 February 1985.

W88-70557 **692-40-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
WVR HARDWARE AND SCIENCE SUPPORT
M. A. Janssen 818-354-7247

This RTOP is intended to provide continuing support for water vapor radiometer (WVR) activities within the Crustal Dynamics Program. A main objective of this task has been to provide science and hardware support to Goddard Space Flight Center for the J-series WVR's. The J-series WVR was developed at JPL, and the original unit (J01) has been operational for two years. Bendix Field Engineering Corporation (BFEC) is currently constructing four more units under contract to GSFC. The funding provided by this task has maintained the field-worthiness of J01, supported continued testing and calibration, enabled improvements in both the software and hardware, and provided for the transfer of the technology to BFEC. Maintenance and improvement of J01 as well as tasks generally related to the J-series WVR's will continue under this RTOP, although a reduced level of support is now required. The emphasis will shift in FY88 instead to the more general problem of the absolute calibration of path delay as determined from the microwave emission of atmospheric water vapor. This calibration will be carried out in collaboration with Dr. Peter Bender and Steve Walter of the University of Colorado. A Water Vapor Calibrator built at the University of Colorado under separate Crustal Dynamics funding will be used to directly measure the line-of-sight radio path delay between an airplane and a ground station at the same time that the microwave emission of the atmosphere is measured with a well-calibrated WVR. The

measurements will be made under a variety of atmospheric conditions so that a general expression for the microwave absorption of atmospheric water vapor may be obtained. The work by the University of Colorado will be supported under separate funding. JPL's role will be to provide absolutely calibrated atmospheric emission measurements, and to obtain the final expression for water vapor absorption. This result will allow radio path delay measurements to be obtained from WVR's with much greater absolute accuracy than is presently possible.

W88-70558 **692-60-42**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VARIABLE EARTH ROTATION
C. F. Yoder 818-354-2444

This RTOP is intended to support general scientific research related to interpretation of Crustal Dynamics Program (CDP) earth orientation data (UT1, polar motion and nutation) and Lageos orbit perturbations, particularly the secular changes in J2, J3, J4, etc. The primary topic concerning earth rotation is the construction of a more complex nutation model which takes into account oceans, solid friction, and earth model uncertainties. In addition, the effect of the inner core, core-mantle boundary layer, figure-figure core-mantle coupling and the non-hydrostatic gravity field will be examined. The principal objective for this task is to determine how well nutations constrain the core-mantle ellipticity. A layered earth model has already been developed to examine how viscosity structure and melting history affect present day changes in gravity field. A model describing the lateral dependence on viscosity structure is being developed which uses the tomographic lateral velocity variations to infer temperature viscosity variations. The principal objective is to determine how well observables such as the secular change in J2 and polar motion constrain viscosity structure.

W88-70559 **692-60-43**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LUNAR LASER RANGING DATA ANALYSIS
J. G. Williams 818-354-6466
(692-60-61)

The analysis of the lunar laser range data is intended to determine parameters of geophysical and geodetic interest as its final product. These parameters are station locations, their rates, the earth's gravitational mass (GM), tidal acceleration of the moon, and precession and nutations of the earth's rotation axis in space. These determinations will contribute to precision geodesy and the understanding of continental drift, tides, the moments of inertia of the earth, and the earth's interior structure. The continued processing of lunar-range data will improve upon the accuracies of these determinations as newer, more accurate ranges are received. The software needs improvements at the 1 to 2 cm level to fully use the accuracy (4.5 cm) of the best ranges received to date. Principal among these improvements are changes in the earth tide model for variable Love numbers, solid body pole tide, and ocean loading. Also intended are upgrades in the software for operational efficiency, particularly in the calculation of dynamical partial derivatives. The lunar laser ranging (LLR) origin of terrestrial longitudes has been held fixed for several years to prevent annoying shifts from one solution to another. Solutions show that a shift of 0.02 arcseconds is needed to preserve consistency between that origin, the BIH origin for universal time (UT1), and the dynamical equinox. This resetting of the origin will be done. The work of this investigation will also benefit the regular operational determination of earth rotation and the monitoring of data quality of the related RTOP.

W88-70560 **692-60-45**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CRUSTAL STRAIN MODELING USING FINITE ELEMENT METHODS
G. A. Lyzenga 818-354-6920
(692-40-40)

The objectives of this RTOP are the development and application of numerical modeling methods for understanding the time dependent deformation of the earth's crust in active tectonic zones. This research has direct relevance to the interpretation of measurements currently being carried out by the Crustal Dynamics Project. In work under the related RTOP, kinematic descriptions of the state of crustal deformation in monitored regions is obtained. The task described in the present RTOP addresses the underlying physical processes giving rise to the observed motions. The approach employed in this task uses the finite element method to construct time dependent models of tectonic deformation in spatially inhomogeneous domains. This approach allows the description of realistic configurations of faults and variable material properties, not amenable to analytic techniques. The utility of such models is to provide a theoretical link between geodetic observations and data derived from geological sources, as well as to constrain the physics of earth deformation processes.

W88-70561 **692-60-46**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL TECTONIC MOTIONS
T. M. Eubanks 818-354-7218

The proposed research is intended to continue the study of present day plate motions using earth orientation measurements, and the related production of earth orientation series which account for tectonic motions of the participating geodetic observatories. This RTOP can be divided into two tasks, analysis of publicly available earth orientation data, and the re-reduction of Infrared Interferometer Spectrometer (IRIS), Polaris, and Crustal Dynamics Program Mark 3 very long base interferometry (VLBI) data at JPL using JPL software. It should be noted that the inherent accuracy of VLBI baseline orientation motions through orientation measurements will thus both complement the more traditional study of length changes and serve as an important source of new information, without requiring the acquisition of any additional data. The first task will involve the re-reduction of the IRIS/Polaris VLBI data with an independent JPL software package providing both the length and orientation determinations. The length and orientation of each baseline in the network will be estimated each time it is observed to provide the detailed geodetic results necessary for a complete analysis of network deformation. These data are not currently publicly available from any source. This task will produce determinations of the velocity of relative motions between Europe and America with formal errors of 1 centimeter/year or smaller from both orientation and length data and will greatly increase the confidence in rate estimates from changes in baseline length. The second task will use publicly available earth orientation measurements (Satellite Laser Ranging, Lunar Laser Ranging, and VLBI from other sources: NASA Geodynamics Program and the Deep Space Network) together with baseline orientation results from the first task, to study the slow divergences in the observed earth orientation caused by plate motions. This task will produce tectonic motion estimates with formal errors of 1 to 2 centimeters/year or smaller from locations on the North American, European and Australian plates. The resulting drift rate estimates will be compared with geological plate motion models and with other geodetic motion estimates.

W88-70562 **692-60-47**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ANGULAR MOMENTUM
T. M. Eubanks 818-354-7218

The objective of this investigation is to obtain a better understanding of the exchanges of angular momentum which cause the polar motions and changes in the earth's rotation rate, (the length of the day). The proposed research can be divided into two tasks, the first of which is entitled Excitation of the Long-Term Decade Fluctuations. Our research has found excellent agreement between rapid variations in the earth's rotation rate and changes in the atmospheric angular momentum. By contrast, little is currently known about the physical processes which cause the long term decade fluctuations in the length of the day (LOD) although it is generally assumed that these are related to torques at the core mantle boundary. This task will attempt to provide better determinations of recent LOD changes and torque estimates, and

to relate these changes to estimates of core-mantle torques produced elsewhere by model dependent calculations. The second task, Atmospheric and Oceanic Excitation of the Polar Motions, will continue our previous research into the excitation of the polar motions. This research has made considerable progress, with the identification of a meteorological role in the excitation of rapid polar motions, and with the discovery of a non-equilibrium ocean response to atmospheric pressure loads at high frequencies. This task will involve continuation and publication of this research, together with investigation into the excitation of the Chandler and Seasonal Wobbles.

W88-70563 **692-60-61**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LUNAR LASER RANGING
J. O. Dickey 818-354-3235
(692-60-43)

The analysis of lunar laser ranging (LLR) data provides a wealth of geophysical and geodetic information. Of importance to the geodynamics community has been the series of measurements permitting long-term studies of variations in the earth's rotation, as well as determination of Universal Time (UTI); the long term stability and temporal resolution are assets of LLR. Timely analysis of LLR data permits quick-look monitoring of the data quality and the rapid determination of earth rotation. For studying the processes which underlie variations in the earth's variation, the long span of LLR data is valuable. LLR has produced new information about the exchange of angular momentum between the solid Earth and the atmosphere; its long series has had implications on the study of the longer-term fluctuations in earth rotation, the so-called decade variations. The analysis of LLR earth rotation together with LAGEOS results reveals variations in the zonal gravitational harmonic coefficient, J2, which constitutes the first unambiguous demonstration of a secular change in the earth's gravity field. Tasks planned under this activity include: the analysis of LLR data in a timely fashion, continued earth rotation determination and their distribution to the NASA Programs, the BIH, and the general scientific community, intercomparison of LLR earth rotation results with those from other techniques, generation of a new export lunar ephemeris needed for LLR analysis. With the advent of ranges with accuracies better than 5 cm, a new lunar ephemeris is desirable and is needed. The previous ephemeris benefited from 10 cm accuracy data; hence, a significant improvement is expected, interaction with the various LLR sites and stations; NASA and the Crustal Dynamics Program on data quality and quantity as well as University of Texas on normal points generation; publication and presentation of our results. This task is complimented by Lunar Laser Ranging Analysis (RTOP 692-60-43), which covers modeling improvements as well as other tasks.

Laser Network Operations

W88-70564 **693-70-00**
Goddard Space Flight Center, Greenbelt, Md.
LAGEOS 2 (INTERNATIONAL COOPERATIVE PROJECT)
G. W. Ousley, Sr. 301-286-8073

The objective of this RTOP is to provide a cooperative U.S./Italian spacecraft to be used by the Crustal Dynamics Project. (A NASA Lageos was launched in 1976.) The approach is based on a Memorandum of Understanding between NASA and Italy. Italy will provide the spacecraft, upper stage, and apogee kick motor. NASA will provide a launch on the Space Transportation System (STS), laser tracking of the satellite and laser optical characterization of the satellite.

W88-70565 **693-90-10**
Goddard Space Flight Center, Greenbelt, Md.
CRUSTAL DYNAMICS
R. J. Coates 301-286-8809

The scientific objectives are to improve the knowledge and understanding of: (1) regional deformation and strain accumulation related to large earthquakes in the plate boundary regions in western North America; (2) contemporary relative motions of the North American, Pacific, South American, Nazca, Eurasian, and Australian Plates; (3) internal deformation of continental and oceanic lithospheric plates, with particular emphasis on North America and the Pacific; (4) rotational dynamics of the earth and their possible correlation with earthquakes, plate motions, and other geophysical phenomena; and (5) regional deformation in other areas of high earthquake activity. In order to achieve these objectives, an extensive measurement program utilizing both Very-Long-Baseline Interferometry (VLBI) and Satellite Laser Ranging (SLR) is underway. Frequent high-accuracy measurements of baselines between many stations in active areas near plate boundaries are being made to determine regional deformation and strain accumulation. Baselines between a global set of stations are being measured repeatedly to determine relative plate motions. Repeated measurements of baselines between several stations on the same plate are being made to determine the internal deformation of the plate. Polar motion and earth-rotation variations are derived from daily measurements with a global set of stations in stable locations.

Mars Observer

W88-70566 **838-59-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DEVELOPMENT OF THE PRESSURE MODULATOR INFRARED RADIOMETER
D. J. McCleese 818-354-2317

The objective of this task is the development of advanced infrared instrumentation for NASA's program of planetary exploration from spacecraft. The emphasis is on the following atmospheric science goals: (1) determine the thermal structure and its spatial and temporal variability in the terrestrial and outer planets; (2) map the abundance and vertical, lateral and temporal variability of key atmospheric species; (3) measure, by direct and indirect means, atmospheric motion; and (4) determine the physical properties of clouds and aerosols. The investigation of surface phenomena is also of fundamental importance in the rational development of infrared instrumentation. In particular our objective is the application of infrared remote sensing to the determination of surface thermal balance, thermal inertia measurements and the mapping of surface morphology. The approach will be to develop in the laboratory the critical hardware for an advanced infrared sounder. During FY88 this task focuses on the definition and development of the Pressure Modulator Infrared Radiometer (PMIRR) for the proposed Cassini Saturn orbiter/Titan Flyby mission. The PMIRR employs pressure modulation and narrowband filter radiometry in both limb and nadir sounding modes, to obtain simultaneous vertical profiles of temperature, pressure, selected chemical species and aerosols in the atmospheres of both Saturn and Titan. The PMIRR instrument concept has been developed into the instrument selected for Mars Observer, and has a substantial heritage of flight proven hardware applications on earth and Venus orbiting spacecraft.

W88-70567 **838-59-06**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IR MAPPER
H. M. Liaw 818-354-6817

The overall objective of this RTOP is to develop the visible and infrared imaging spectrometer (VIMS) for future solar system missions. Current investigation objectives are to optimize the VIMS design for the post Cometary Rendezvous Asteroid Flyby (CRAF) missions with emphasis on the Lunar Geoscience Observer (LGO), Cassini and NEAR; to investigate options to reduce weight, complexity and cost; and to extend the wavelength coverage and improve performance. Technical analyses and development efforts are pursued simultaneously in the following areas for the instrument system: (1) analyses of the scientific goals and other mission requirements and assessment of instrument similarities and

differences; (2) study of instrument issues and technologies; (3) development of the instrument concept for each of the missions; and (4) preliminary development of key components for the instrument. Key components and issues currently being addressed include optics, detector arrays, cooling, electronics, structural and mechanical design, sensor data processing, and system analyses. Progress is being made on the following topical investigations: holographic application in diffraction gratings and reduction of reflecting surfaces to improve performance and reduce complexity; sensor system modeling; testing of HgCdTe, InSb and PtSi detector arrays; analysis of imaging in the long wavelength infrared spectral region; study of cooling requirements for the LGO and radiative cooler designs; sensor data processing algorithms; and a feasibility study of an uncooled VIMS using pyroelectric detector arrays.

W88-70568 **838-59-07**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ROVER IMAGING SPECTROMETER
J. B. Wellman 818-354-6638

This RTOP will serve as the initial funding for an effort to develop an on-board multispectral imaging spectrometer for the Mars Rover. This effort will concentrate on evaluating the mission science requirements and designing an imaging spectrometer which best meets these needs. It is anticipated that the instrument will have spectral response consistent with the Mars Observer Visible and Infrared Mapping Spectrometer (VIMS) instrument. The objectives for the first year are: (1) mission scientific requirements and instrument performance requirements analysis; (2) instrument overall system analyses and concept definition; and (3) investigation of key components and technical issues including the optics, detectors, cooler, electronic subsystem, structural and mechanical and sensor data processing. Additionally, areas requiring further effort of development will be identified and the development planned out. To fulfill the objectives, the following approaches will be pursued: specify instrument performance requirements with the science team, analyze existing baseline spectrometer design against the requirements, define the optimal instrument concept for the mission while pursuing key components technology preliminary development.

Sounding Rockets

W88-70569 **879-11-38**
Goddard Space Flight Center, Greenbelt, Md.
SOUNDING ROCKET EXPERIMENTS
W. M. Neupert 301-286-3756

The sounding rocket program provides unique capabilities to conduct a broad range of scientific investigations. The program is particularly important for the development and demonstration of the merit of new instruments for shuttle flights and of prototype instruments for satellites. Furthermore, the short lead time and program flexibility make it possible to follow up new discoveries and to study particular phenomena on the sun and in the earth's atmosphere. Extreme ultraviolet (EUV) spectra of the sun are a valuable tool for determining the true physical conditions in the solar corona and in understanding the flow of matter and energy in the sun's outer atmosphere. For this purpose, we need to know the coronal density, temperature, gas velocity, and radiation field. The work under this task is directed toward the development and flight on sounding rockets of instruments for determining these four physical parameters in the corona. A major objective is to measure coronal gas velocity as a function of position on the solar disk. Another objective is to determine the coronal temperature, density, and line excitation processes by combining a knowledge of line profiles with the relative line strengths. A third objective is the investigation of wave propagation and dissipation, which may be fundamental to understanding energy transport in and heating of the corona.

W88-70570 **879-11-41**
Goddard Space Flight Center, Greenbelt, Md.
SOUNDING ROCKET EXPERIMENTS (ASTRONOMY)
Andrew M. Smith 301-286-8648

The astronomical sounding rocket program provides a unique capability to perform observations from above the earth's atmosphere. The present objectives are to develop instrumentation which takes advantage of this capability and to obtain spatial images of faint extended celestial sources in the vacuum ultraviolet (VUV) and far ultraviolet (FUV). The emphasis in our instrumental development program is on photon counting, two dimensional array detectors optimized for astronomical applications. This effort includes research into techniques for implementing centroiding logic and into methods of adapting the Multi-Anode Microchannel Array (MAMA) detector to our sounding rocket needs. Work is also planned to provide image motion compensation and an imaging spectrograph for our sounding rocket telescope. The instrumental development results from our group's scientific interests. These include observations of faint extended objects such as condensations in cooling flows of intercluster gas, jets associated with active galaxies, and giant luminous arcs in galactic clusters.

W88-70571 **879-11-46**
Goddard Space Flight Center, Greenbelt, Md.
SOUNDING ROCKET (SPARTAN) EXPERIMENTS (HIGH ENERGY ASTROPHYSICS)
E. A. Boldt 301-286-5853

High energy astrophysics (especially X-ray astronomy) is a rapidly evolving field of research, both scientifically and technically. Our exploitation of the capabilities of short lead time, planning flexibility, accurate pointing and extremely high telemetry rates afforded by rocket-borne experiments are major factors in our success to date; a vigorous elaboration of this activity with Spartan as well as sounding rockets is now necessary for continuing to make timely and important contributions that complement data from our satellite missions and for the effective planning of advanced future missions. This involves experiments with systems incorporating newly developed spectrometers and X-ray concentrators.

W88-70572 **879-11-46**
Marshall Space Flight Center, Huntsville, Ala.
X-RAY ASTRONOMY
M. C. Weisskopf 205-544-7740

Research will be conducted in the field of X-ray astronomy in areas related to the Astrophysics programs of NASA. The first major objective of this program is to analyze and interpret existing satellite and ground-based observations of the time variability of X-ray sources and their optical counterparts. Fourier transform, epoch folding, and auto- and cross-correlation techniques will be utilized to classify and quantify the time variability of these sources. The results will be interpreted in terms of existing theoretical models or to establish new theoretical models if required and feasible. These results will be utilized in guiding the design of the sounding rocket payload. The second major objective is to develop new methods and systems for detecting X-ray polarization. An advanced X-ray imaging detector will be designed, built, tested, optimized, and eventually flown on sounding rockets and satellites. The detector will utilize fluorescence of the atoms in the detector gas together with parallel field preamplification regions to obtain the highest performance. This has application for X-ray imaging, spectroscopy, and polarimetry.

OFFICE OF SPACE TRACKING AND DATA SYSTEMS

Advanced Systems

W88-70573 **310-10-23**
Goddard Space Flight Center, Greenbelt, Md.

SOFTWARE ENGINEERING TECHNOLOGY
Frank E. McGarry 301-286-6846
(506-54-56; 310-40-49)

The objective of this RTOP is to identify, evaluate, and refine software engineering technology as applied to the software development process for the NASA environment. The technology to be studied includes: (1) software development methodologies such as structured implementation techniques, various testing techniques, structured analysis approach to design; (2) software development tools such as code auditors and analyzers, configuration management aids and PDL processors; (3) software measures and models such as cost and reliability estimation models; (4) the Ada language and associated development techniques; and (5) techniques for increasing reusability of software. The identified methodologies are intended to significantly reduce the overall life cycle costs of the software within the Mission Operations and Data Systems area. The approach to attain the stated objectives includes the utilization of an experimentation laboratory wherein proposed tools, methodologies and models may be acquired, developed, applied and studied in an actual software production environment. This laboratory, called the Software Engineering Laboratory (SEL), first of all identifies technologies of potential benefit to the NASA software development process, then identifies appropriate measures for assessing the impact of the technology and coordinates the detailed experimentation of applying and tuning the technology within selected software development projects supporting various requirements of Mission Operations and Data Systems. Each of the projects is then carefully studied to determine the impact within the NASA software development environment and to further identify refinements or additional technologies (tools, models, technologies, language characteristics, etc.) that could positively impact NASA software and would be directed at addressing specific NASA software shortcomings.

W88-70574 **310-10-26**
Goddard Space Flight Center, Greenbelt, Md.
FLIGHT DYNAMICS TECHNOLOGY
E. V. Seidewitz 301-286-7631

The objective of this RTOP is to develop, evaluate, and demonstrate new technology for flight dynamics in the Tracking and Data Relay Satellite System (TDRSS) and Space Transportation System (STS) era, encompassing algorithms, techniques, software, and hardware for attitude and orbit determination, prediction, and analysis for both ground-based and onboard application. The technology developed under this RTOP supports the Office of Space Tracking and Data Systems in the areas of mission computing and analysis, TDRSS operations, and data processing. The approach for the various tasks is as follows: (1) Task 1, COBE Flight Experiment: develop, demonstrate, and evaluate one-way Doppler tracking via TDRSS multiple access return link using an ultrastable oscillator onboard a user spacecraft; (2) Task 2, Orbit Determination Automation: develop, demonstrate, and evaluate orbit determination automation techniques; (3) Task 3, Sequential Orbit Determination: study orbit determination using sequential filtering; (4) Task 4, PC Software Tool for Analysis and Reconfiguration (PCSTAR): develop a reconfigurable PC-based attitude dynamics simulation tool; and (5) Task 5, Advanced Attitude Determination: study and develop advanced, generic attitude determination methods.

W88-70575 **310-10-60**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RADIO METRIC TECHNOLOGY DEVELOPMENT
C. D. Edwards 818-354-4408
(310-10-61; 310-10-62; 310-10-63; 310-30-68)

The broad objective of this RTOP is to design and demonstrate improved techniques of radio metric data acquisition and analysis as used by the Deep Space Network (DSN) to support navigation and radio science. Central to this goal is understanding the limiting error sources for various radio metric data types and observation scenarios. The current approach to improving navigation accuracy largely consists of refining methods of angular spacecraft navigation using interferometric techniques, primarily Very Long Baseline Interferometry (VLBI). Much of the work in the RTOP involves the analysis of VLBI experiments designed to probe particular error sources. Based on these experiments, improved modeling and calibration techniques are developed to reduce or eliminate dominant errors. In addition, optimal observing strategies are designed to improve differential spacecraft-quasar navigation measurements. These efforts are aimed towards developing a 5 nrad angular measurement accuracy by the mid-1990s. To advance the capability for target-relative navigation, several observational programs are being pursued to improve the tie between the planetary ephemeris and the radio reference frames. Connected element interferometry (CEI) techniques could provide high efficiency angular navigation for the DSN, using baselines of 10 to 100 km in length. Realtime correlation of CEI data would reduce navigation turnaround time, while improving experimental reliability by providing on-line verification. Short baseline intracomplex interferometry experiments are currently being performed to quantify the navigation potential of CEI. Achieving angular accuracy below 50 nrad on intracomplex baselines will require reducing a variety of delay error sources to the 1 mm level. Prototype realtime correlator designs will be investigated, leading to a realtime navigation demonstration in future years.

W88-70576 **310-10-61**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EARTH ORBITER TRACKING SYSTEM DEVELOPMENT
T. P. Yunck 818-354-3369
(310-10-60; 310-10-63)

The objective of this RTOP is to develop the conceptual design for an integrated system to track earth satellites-low earth orbiters (LEOs), highly elliptical orbiters (HEOs), and geosynchronous orbiters (GEOs) and to demonstrate its feasibility. The goal is to surpass current tracking accuracy by roughly an order of magnitude in a system that is economically practical to deploy and operate. Nominally, the system should yield position accuracies of a few decimeters or better at altitudes below 3000 km, increasing to 1 to 5 meters at geosynchronous altitude. It will include six to ten ground terminals, three provided by NASA at the Deep Space Network (DSN) sites, which will be compact and operate unattended. The system will be able to determine the non-DSN receiver locations with respect to the DSN reference sites with few-centimeter accuracy and will be able to provide continuous tracking for a large number of satellites. A further objective of the RTOP is to study the application of this system to prospective NASA missions and to consider, in general, future NASA Earth orbiter tracking needs and the systems that might be used to meet them. The tracking system proposed here will employ signals from the satellites of the Global Positioning System (GPS) being developed by the Department of Defense. The technique employs differential GPS observables constructed from observations made concurrently with GPS receivers on the ground and on low orbiters. Higher orbiters, above about 10,000 km, would carry a beacon rather than a GPS receiver. Other work under this RTOP includes system design and performance analysis, error analysis software development, study of the use of GPS for earth orientation measurement, and demonstrations of the tracking techniques on the GPS satellites and on future LEOs as opportunities arise. Related work is being done under sponsorship of the Oceanic Processes and Geodynamics branches of the Office of Space Science and Applications (OSSA).

W88-70577 **310-10-62**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FREQUENCY AND TIMING RESEARCH
L. Maleki 818-354-3688
(310-10-60; 310-10-61; 310-10-64; 310-10-68)

The objective of this RTOP is to develop and demonstrate the technology of precise frequency and timing in support of Deep Space Network (DSN) missions and radio science activities. The goal of frequency stabilities pursued in the RTOP is demonstration

of the capability of one part in 10 to the 16th power at averaging intervals between 1 and 10 to the 4th power seconds in the Goldstone complex by 1990. The long term goal is the demonstration of parts in 10 to the 17th power capability for averaging intervals between 1 second and 10 to the 5th power seconds in the 1990s. The work planned is in three areas. First, the generation of precise frequencies, to meet the goals above, will be developed through the demonstration of the trapped mercury ion frequency source, the superconducting maser oscillator, and the super cooled quartz oscillator. Work will also be carried out to develop the required technology to achieve one part in 10 to the 16th power stability at 1000 seconds in the hydrogen maser. Second, the distribution of precise frequencies will be demonstrated through the development of fiber-optics systems including stabilized cables. A systems study will also analyze and engineer a centralized frequency distribution system for a DSN complex. This work will provide techniques for efficient distribution of the precise signals generated by frequency sources without stability degradation. Third, work will be performed on the development of a frequency stability measurement and monitor capability. This effort will provide real time information on the status of the stability of precise frequencies generated, distributed, and used throughout a deep space station.

W88-70578 **310-10-63**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE SYSTEMS AND NAVIGATION TECHNOLOGY
C. S. Christensen 818-354-7408
(310-10-60; 310-10-61; 310-10-67)

The objectives of this RTOP are to: (1) investigate new navigation technologies; (2) develop techniques to increase the accuracy and decrease the costs and time for navigation data processing in the Deep Space Network (DSN); and (3) develop a synergistic relationship with advanced mission planning teams that promotes the optimum growth of both DSN and spacecraft navigation capability. To meet these objectives the RTOP focuses on three primary areas. The first area, navigation technology, identifies and evaluates data strategies for improving deep space navigation accuracies, and enhancing mission capabilities. Radio metric data needs for new navigation functions, such as asteroid and comet orbiters, are investigated. Navigation concepts and data strategies consistent with low-cost mission support are formulated and demonstrated using data from current missions. New and novel navigation technologies are investigated. Technology is being developed for improving quasar-relative solar system target body location accuracies. The second area focuses on reducing mission operations costs and increasing throughput and reliability by the automation of radio metric data processing. Technologies being pursued are: development of high-speed computer graphics capabilities, the investigation of navigation uses of expert system technology, and the initiation of automated event-driven operations and diagnostic procedures. The third area establishes system level requirements for Quasat, an earth orbiting antenna to be used to acquire very long baseline interferometry (VLBI) data. The initial objectives of demonstrating, using the Tracking and Data Relay Satellite System (TDRSS), the feasibility of transferring ground based stable frequency standards to an earth orbiter and of obtaining interferometric fringes using the TDRSS single access antenna and a DSN station, were accomplished in FY87.

W88-70579 **310-20-33**
Goddard Space Flight Center, Greenbelt, Md.
NETWORK SYSTEMS TECHNOLOGY DEVELOPMENT
George C. Kronmiller, Jr. 301-286-7313

The objective of this RTOP is to investigate the applicability of new technology in the Tracking and Data Relay Satellite System (TDRSS) era. Selected technology will be investigated by means of feasibility studies, prototype development and demonstration, and by cost and reliability impact studies. A major goal is to investigate the effect of non-Gaussian channel characteristics on the Space Networks (TDRSS and follow on) link performance and develop coding and signal designs which optimize link performance. Associated with this goal are the objectives of validating the analytical predictions by means of tests utilizing the actual network hardware, developing the capability to predict communications link performance against a mission flight time line and utilizing expert systems techniques to enhance system operation and minimize analyst manpower requirements. Other elements associated with achieving this goal are modifications of the Communications Link Analysis and Simulation System (CLASS) to provide a network design and evaluation tool as well as a network user communications system design tool. Another major goal is to investigate the potential for use of radio frequency (RF) to intermediate frequency (IF) fiber optic technology in future ground station applications. The extremely wide bandwidth and low loss available in fiber optic cables makes this technology an attractive alternative to coax cable and waveguide. The task will concentrate on the feasibility of transmitting radio frequency signals using fiber optics. In more conventional fiber optic applications, digital signals are transmitted using the electrooptic components as switched devices whereas this experiment will utilize these devices in a linear mode.

W88-70580 **310-20-38**
Goddard Space Flight Center, Greenbelt, Md.
NETWORK COMMUNICATIONS TECHNOLOGY
Sajjad H. Durrani 301-286-7338

The objectives of this RTOP are: (1) to introduce an efficient high-rate digital telecommunications system into the NASA Communications (Nascom) network; (2) to develop improved interfaces with commercial telecommunications systems; (3) to investigate new technologies and techniques for use in Nascom; and (4) to develop modeling tools to assist in system optimization, leading to reduced implementation and operations costs. The RTOP started in FY86 with four tasks. Each task was to span two or three years and encompass analysis, simulation, and prototype hardware and software development. One task was dropped and four new tasks were added in FY86, as in-house skills and capabilities increased. All seven tasks were continued in FY87. They were: 300 Mbps modem; protocol evaluation; Nascom gateways; Local Area Network (LAN) technology; automated fault isolation; TDMA scheduling; and network modeling. Two tasks (LAN technology and TDMA scheduling) will be completed in FY87. The FY88 program will include the five ongoing tasks from FY87, plus two new ones: high speed fiber optics LAN technology and computer aided design techniques. Preliminary work on these new tasks was initiated in-house in the second half of FY87.

W88-70581 **310-20-39**
Goddard Space Flight Center, Greenbelt, Md.
VERY LONG BASELINE INTERFEROMETRY (VLBI) TRACKING OF THE TRACKING AND DATA RELAY SATELLITE (TDRS)
Philip Liebrecht 301-286-8003

The objectives of this RTOP are to utilize VLBI Tracking of the TDRS's as an independent measure with which to validate the TDRSS tracking capability, to demonstrate the application of passive interferometric techniques to improve TDRS trajectory determination, and to develop system functional requirements and descriptions for an operational, dedicated TDRSS interferometric tracking system. A two-phased approach will be used. During the first phase, experiments will be conducted to demonstrate the feasibility of the technique, and provide data for evaluation of different design alternatives, and comparison with the Bilateration Ranging Transponder (BRTS) derived orbits. The second phase will involve formulating and documenting overall functional requirements and system analysis for a dedicated operational TDRSS tracking system.

W88-70582 **310-20-46**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED SPACE SYSTEMS FOR USERS OF NASA NETWORKS
R. P. Hockensmith 301-286-9067

The objective of the work under this RTOP is to achieve technological advances in radio frequency (RF) and optical systems, antenna subsystems and associated control technology, on-board data storage systems and telecommunications coding.

These developments will satisfy future requirements of users of NASA networks (spacecraft, space platforms and space transportation system payloads) that require near-global coverage through evolving data relay satellite systems such as the Tracking and Data Relay Satellite System (TDRSS) and other networks as appropriate. The approaches for accomplishing the objective are to: (1) identify the basic operational space flight requirements; (2) investigate active and passive components and antenna systems; (3) investigate methods of reducing and controlling torque noise induced for the steering of large high gain antennas; (4) investigate methods of high density and high rate recording storage and playback; (5) investigate improvements in telecommunication coding of spacecraft generated data; (6) develop system designs to permit User projects to specify proven, reliable hardware with a high confidence level in the performance capability, cost and required procurement cycle; and (7) exploit necessary improvements in testing techniques that properly characterize these critical systems.

W88-70583 **310-20-64**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED TRANSMITTER SYSTEMS DEVELOPMENT
R. Hartop 818-354-3433
(310-20-65; 310-20-60)

The object of this RTOP is the development of advanced transmitter systems that will enhance performance, reduce costs, and improve the reliability of the Deep Space Network (DSN) transmitter functions, including uplink command capability, emergency commanding, radio science, navigation, and radar astronomy. A 20-kW CW 7.2-GHz transmitter at DSS-13 is currently being used to demonstrate a complete ground station frequency stability of 5 parts in 10 to the 15th power when averaged over 1000 seconds. The transmitter has also been used in conjunction with 2-GHz transmitter and receiver subsystems to investigate simultaneous S- and X-bank uplink-downlink operations. These tests have demonstrated the technology for simultaneous uplinks at widely-spaced frequencies for future DSN use. The design of a state-of-the-art transmitter system from the output of a frequency standard at 100 MHz or higher to the feedhorn output at X- or Ka-band has been initiated. This transmitter system will feature advanced technology in several areas including very high phase stability, high reliability, and complete microprocessor monitoring and control. The resulting transmitter technology will be applicable to any DSN requirements such as the planned implementation of 20-kW 7.2-GHz transmitters on the 70-meter network beginning in 1990. Another work unit will develop techniques for combining multiple high power sources in an efficient and versatile manner, including beam waveguide environments. A continuing work unit provides Ka-band systems analysis to define ground systems support requirements, such as those for the Mars Observer and Comet Rendezvous Asteroid Flyby Missions.

W88-70584 **310-20-65**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ANTENNA SYSTEMS DEVELOPMENT
A. Cha 818-354-3509
(310-20-64; 310-20-66; 310-20-68)

The objectives of this RTOP are to develop and demonstrate electromagnetic, optical, and structural mechanical technology to increase the capabilities of the large antennas in the NASA Jet Propulsion Laboratory (JPL) Deep Space Network. Capability improvements include increased frequency band coverage, simultaneous multifrequency operation, increased gain and reduced noise temperature performance, and reduced maintenance and operations costs. Recent development initiated in this RTOP include common aperture feeds that operate simultaneously at 2 and 8 GHz, 64 m antenna structural bracing, two axis automated subreflector focusing, and 34 m High Efficiency as well as the 64-70m antenna extension combined with high-precision shaped dual-reflector technology. Present objectives are to: (1) design a wideband, high-performance beam waveguide antenna replacement to the DSS-13 experimental station; (2) achieve high accuracy and stable radio frequency (RF) beam pointing consistent with 32-GHz performance; (3) evaluate 70 m antenna RF performance and outline an upgrade program containing affordable options; and (4) use microwave holography to achieve high-precision reflector surfaces. Our approach uses computational-intensive synthesis and analysis software appropriate to the large high-frequency reflectors, and demonstrations and tests to reduce implementation risks in order to verify analytical models and understand critical areas needing cost-effective improvement.

W88-70585 **310-20-66**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RADIO SYSTEMS DEVELOPMENT
J. J. Bautista 818-354-6994
(310-30-68)

The objectives of this RTOP are to develop and demonstrate receiver system technology that will lead to ground-based improvements in the spacecraft-to-earth communications link. The improvements sought are increased performance, reduced implementation and modification costs, and increased reliability of receiving equipment and cryogenic systems. These improvements address future Deep Space Network (DSN) navigation, telemetry, radar, and radio science needs. A key figure of merit in the specification of the communications link to a deep space mission is the ratio G/T, that is, the gain of the ground-based antenna divided by the system noise temperature. This RTOP addresses the persistent need to keep the system noise temperature as low as technology permits. The primary concern of this RTOP is the development of low-noise amplifiers to cover 2.3, 8.4, and 32 GHz with broad bandwidths and high gain and phase stability. Both 32-GHz masers and solid-state amplifiers using high-electron mobility transistors (HEMTs) are being developed, as well as the analytical tools and measurement systems needed for designing and characterizing maser-slow-wave structures, HEMT devices, and microwave low-noise amplifiers. Additional work is aimed at the development of microwave cryogenic devices using very low-loss superconducting materials for fixed and tunable radio frequency interference (RFI) protection filters and maser slow-wave structures. There is a continuing effort to provide for future cryogenic refrigeration needs of low-noise amplifiers by improving the mean time between failures (MTBF) and cooling efficiency at present 4.5-K systems and by developing a 1.5-K liquefier system appropriate for use on antennas with beam waveguide feed systems.

W88-70586 **310-20-67**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL COMMUNICATIONS TECHNOLOGY DEVELOPMENT
J. R. Lesh 818-354-2766
(310-20-63)

The objective of this RTOP is to develop and demonstrate a reliable and efficient optical communications and tracking capability for use with Deep Space Network (DSN) supported missions in the mid-1990s and beyond. The work will concentrate on the definition, design, development, and analysis of communications and tracking systems that could support such missions, and will include the development and use of high-leverage technologies that have a major influence on the character of those systems. The RTOP will focus first on direct-detection optical technology, of greatest benefit to outer-planet missions, and second on heterodyne technology, for inner-planet missions where there are high background noise levels. This RTOP will not involve determination of actual requirements for spacecraft optical equipment, nor will it develop space-qualified hardware. It will involve the design, development, fabrication, and testing of laboratory and other ground-based demonstrations of the technology for optical communications and tracking. Flight demonstrations of the technology will be pursued only through the initial design and planning stages, so that appropriate sources of funding can be identified. Optical techniques for communication and tracking are expected to be of greatest value when used between planetary spacecraft and an Earth-orbiting communications and tracking terminal. Such a terminal would be deployed initially in a low Earth orbit, possibly aboard the Space

Station, with future deployments in geosynchronous orbit. However, studies indicate that even ground-based optical systems could provide acceptable communications and tracking performance. Accordingly, this RTOP will also include examination of the design, cost and performance factors of ground-based systems. Major deliverables for the RTOP are the design and analysis of a ground-based R and D reception station (FY89), creation of a calibrated optical weather model (FY90), and demonstration of a heterodyne reception system (FY93).

W88-70587 **310-20-68**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STATION MONITOR AND CONTROL TECHNOLOGY
R. B. Crow 818-354-6016
(310-10-60; 310-10-62; 310-20-64; 310-20-65; 310-20-66; 310-30-70)

This RTOP will develop and demonstrate the monitor and control (M and C) technology that will be used to operate the Deep Space Network (DSN) of the future. The number of computers in a DSN station is increasing rapidly and as it does individual subsystems tend to become more capable and more complex. Human beings must diagnose failures in a very complex system and then take corrective action. These subsystems must exchange information with each other, be guided from a central point, and report their status to someone or something that is capable of deciding whether the subsystem is performing its assigned function properly. The challenge that this RTOP will meet is twofold. First, to find and utilize the best available methods for computer-to-computer communications. Second, to find and utilize the best available methods to make the data available from these computers understandable to human beings so that crucial decisions can be made with minimal loss of station function. Given the explosion of computer technology that is now underway, the RTOP will concentrate less on development and more on the evaluation of commercially available products with the objective being their integration and demonstration in the environment of a DSN tracking station. The most immediate goal of this RTOP is to develop a M and C architecture that will meet future DSN needs and a plan to demonstrate a working system at DSS 13. Resource allocation and implementation is subject to an early design review.

W88-70588 **310-30-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NETWORK SIGNAL PROCESSING
W. Hurd 818-354-2748
(310-30-68; 310-30-71)

The purpose of the RTOP is to investigate, develop, test and demonstrate advanced signal processing techniques and systems which enable the Deep Space Network (DSN) to plan and achieve its performance requirements with improved reliability, maintainability and operability. The largest task is to develop an advanced receiver for the DSN, including carrier tracking, telemetry demodulation and detection, and Doppler extraction. Key objectives are: (1) to improve telemetry signal-to-noise ratio (SNR) performance relative to existing DSN systems by 1 dB to 3 dB; (2) to increase data rate capability from approximately 500 ksymb/s to 10 Msymb/s in the near term and to 1 Gsymb/s in the long term; (3) to achieve Doppler extractor frequency stability of 10 to the minus 17th power, and (4) to improve the man-machine interface as compared with existing DSN receivers. Major objectives of other ongoing tasks are: (1) to develop a new DSN spectrum surveillance system with sensitivity comparable to the weakest spacecraft signals; (2) to develop custom very large scale integrated (VLSI) circuits for signal processing as cost, speed, complexity, size or reliability dictate; and (3) to develop radio frequency (RF) and intermediate frequency (IF) assemblies for the receiver. The objective of a new task, added in late FY87, is to develop wideband digitization systems for use at RF and IF, thereby reducing complexity of receiving systems. During FY88 the main tasks are: (1) to complete development of a 15 MHz bandwidth advanced receiver-Doppler extractor; (2) to complete hardware board development for the spectrum surveillance system; (3) to complete one VLSI chip for a custom signal processing application; and (4) to begin the RF digitizer system.

W88-70589 **310-30-71**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COMMUNICATIONS SYSTEMS RESEARCH
L. Swanson 818-354-2757
(310-30-67; 310-30-70)

The objective of this RTOP is to develop digital communication systems technology required to meet the needs of Deep Space Network (DSN) supported missions for the 1990s. We focus on improving space communication capability at low cost. The work planned will involve three areas. First, coding/decoding and modulation/demodulation techniques for the future will be investigated, first in order to achieve a 2.0 dB reduction in required signal-to-noise ratio, and then using even more advanced error-correcting and source coding. The initial objective is being met by designing, analyzing and comparing coding systems, some of which may require decoding schemes of higher complexity enabled by new very large-scale integrated (VLSI) circuit technology. The longer-term goal involves new research. During FY88, the 2 dB code will be demonstrated in the laboratory and a spacecraft demonstration will be planned. Second, communication efficiency will be improved for the current codes and technology. For example, the use of image statistics to improve channel decoding of current codes may gain as much as 2.0 dB over the current maximum likelihood decoder in the DSN. During FY88, this work will be expanded to include use of image statistics for decoding during the Goldstone Very Large Array (VLA). Much of this work depends on analysis and computer simulation of various telemetry subsystems for use in evaluating proposed and planned changes in hardware or operations, which is an ongoing activity of this RTOP. Third, new telemetry systems, including decoders for the 2 dB gain, are being developed using microcircuitry technology. This involves mathematical, algorithmic, and architectural research. An 18 chip Reed-Solomon decoder will be demonstrated in the laboratory early in FY88.

W88-70590 **310-40-37**
Goddard Space Flight Center, Greenbelt, Md.
HUMAN-TO-MACHINE INTERFACE TECHNOLOGY
Walt Truszkowski 301-286-8821

The objectives of this RTOP are to develop and apply natural man/machine interfaces for space payload and ground control systems including data base management systems; and develop methodologies, models, interface evaluation tools, and guidelines which emphasize the human factors issues associated with man/machine interfaces and interactions. The intention is to apply recent advances in human factors analysis, data and information base management, and artificial intelligence (AI) to man/machine interface and interaction problems in order to realize development and operational improvements. The approach to be taken is: first, to identify and apply state-of-the-art data/information management technology in the development of interface standards for distributed information access systems; second, to apply human factors analysis, information presentation guidelines and advanced knowledge engineering techniques and methodologies in the development and application of user interfaces to various data/information systems activity used in the mission and data operations environment. The RTOP is a system level RTOP supporting Tracking and Data Relay Satellite System (TDRSS) operations, mission operations, missions support computing, and general systems engineering activities.

W88-70591 **310-40-44**
Goddard Space Flight Center, Greenbelt, Md.
EXPERT SYSTEMS FOR AUTOMATION OF OPERATIONS
Dorothy C. Perkins 301-286-5069

Work under this RTOP will demonstrate the potential of expert systems to automate operations and increase operator capacity by handling routine, labor-intensive tasks and by reducing human task complexity. The development and demonstration of pilot projects which capture functions of control centers will facilitate

the transfer of this technology into operations. Under this RTOP, expert systems will be developed and applied in selected areas to reduce, eliminate or assist human operator decision-making. Projects will be established with the operational divisions to develop proof-of-concept systems and transfer the technology for operational use. Systems will be developed with a phased approach to allow for early hands-on demonstration of Kernel functions to potential users. The transfer of techniques, methodologies and expertise to the operational divisions will be a major goal. This RTOP will also demonstrate the architecture and effects of multiple cooperating expert systems, and will generalize from specific prototypes to multi-application frameworks. It will also support the embedding of expert systems in data systems.

W88-70592 **310-40-45**
Goddard Space Flight Center, Greenbelt, Md.
MISSION OPERATIONS TECHNOLOGY
Henry L. Murray 301-286-2926

The objective of this RTOP is to develop techniques and validate concepts that will improve Spacecraft Control Center operations efficiency and reliability and reduce mission operations costs. The intent of this effort is to apply and evaluate the latest computer graphics technologies, automation technologies and computer languages in the specific command and control environment where the technologies and languages will be used. The approach to achieving this objective has three major thrusts. The first is to study and prototype automation concepts in a spacecraft command and control environment. The spacecraft engineering analysis capability will be developed to enhance the ability of a spacecraft analyst to detect, isolate, and recover from a spacecraft problem. The second thrust is to develop and implement a distributed command and control capability applicable to attached payloads. This thrust will ultimately provide the remote command and control of a spacecraft from the user's location. The third thrust is to assess tools for development of command and control software systems and enhancement of the human/computer language medium. This thrust is presently studying the applicability of artificial intelligence in the area of the man-machine interface for the Multi-Satellite Operations Control Center Application Processor System.

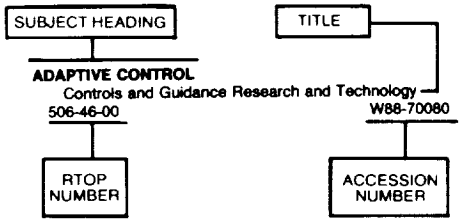
W88-70593 **310-40-46**
Goddard Space Flight Center, Greenbelt, Md.
DATA STORAGE TECHNOLOGY
Frederick W. McCaleb 301-286-3141

This RTOP supports development and utilization of new technology to provide higher performance data storage devices for use in future data capture, data processing and data distribution systems. The approach under Task 1 will be to maintain a Data Storage Testbed System capable of operational demonstration of currently available and future commercial Data Storage Devices. The current goals of the testbed program include continued testing and demonstration of 12-inch optical disk systems and testing and demonstrating rotary digital magnetic tape cassette systems. The approach under Task 2 will be to design and implement a prototype high data rate random access buffer comprising a custom synchronizing controller and an array of high performance controller magnetic disk drive strings. The goal of this task is to demonstrate systolic operation of a sufficiently large array of drives to ascertain whether or not a data buffer of this type is practical to handle multiple 300 megabit per second data channels as is projected to be required for the Space Station Ground Transport System.

W88-70594 **310-40-49**
Goddard Space Flight Center, Greenbelt, Md.
SYSTEMS ENGINEERING AND MANAGEMENT TECHNOLOGY
Dorothy C. Perkins 301-286-5069

The objective of this RTOP is to develop and evaluate systems-level concepts and technologies which will be utilized to optimize the management, operation, and evolution of the Space Tracking and Data Systems (STDS). Major subobjectives are: (1) the development of a systems engineering and management support system for the introduction and consistent use of systems engineering principles and management practices in all phases of the system life-cycle; (2) the development of a database of network models and documentary procedures for systems modeling and simulation; and (3) the definition and phased prototype of an advanced software development environment. The RTOP approach is to develop associated tools and techniques, apply the techniques to representative problems, and evaluate both the techniques and the results prior to full utilization in STDS. This is a system-level RTOP supporting mission operations, mission support computing, spacecraft data acquisition, data processing, and Tracking and Data Relay Satellite System (TDRSS) operations.

Typical Subject Index Listing



A title is used to provide a more exact description of the subject matter. The RTOP accession number is used to locate the bibliographic citations and technical summaries in the Summary Section.

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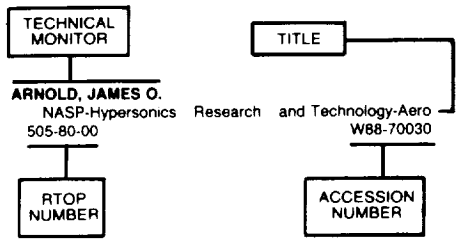
RTOP SUMMARY

Typical Technical Monitor Index Listing



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A

ABBOTT, M. R.
Ocean Productivity
161-30-02 W88-70257
West Coast Satellite Data Visualization
161-30-19 W88-70259

ABRAMS, M. J.
Multispectral Analysis of Ultramafic Terrains
677-41-29 W88-70526

ACKERMAN, T. P.
Climate Modeling Assessment
672-32-01 W88-70459
Ames Multi-Program Support for Climate Research
672-50-01 W88-70460

ACTON, C. H.
Flight Data System Navigation Ancillary Information Facility
656-44-11 W88-70436

ACUNA, MARIO H.
Giotto: Magnetic Field Experiments
156-03-05 W88-70228

ALLAMANDOLA, L. J.
Laboratory Study of Chemical and Physical Properties of Interstellar PAHs
188-41-57 W88-70298

ALLEN, L. B.
Aeroassist Flight Experiment
583-01-00 W88-70121

ALLEN, M.
SME Ozone and MST Radar
673-41-51 W88-70466

ALLISON, MICHAEL
Investigation of Comparative Planetary Dynamics
154-20-80 W88-70207

ALRED, HARRIS
Research and Technology
763-01-00 W88-70138

ALRED, J. W.
Systems Analysis
506-49-00 W88-70092

ANDERSON, B.
Science and Applications Information System (SAIS) Telescience Testbed
450-17-01 W88-70405

ARNAUD, S. B.
Bone Physiology
199-22-32 W88-70325

ARNO, R. D.
Space Station Life Sciences Operations
450-11-02 W88-70387
Space Station Life Sciences Enabled Science
450-16-02 W88-70401

ARNOLD, C. R.
Information Sciences Research and Technology
506-45-00 W88-70073

ARNOLD, D. A.
Controls and Guidance Research and Technology
506-46-00 W88-70079

ARNOLD, J. O.
Aerothermodynamics Research and Technology
506-40-00 W88-70048
Materials and Structures Research and Technology
506-43-00 W88-70060
Space Flight Research and Technology
506-48-00 W88-70087
Research and Technology
763-01-00 W88-70139

ARNOLD, JAMES O.
NASP-Hypersonics Research and Technology-Aero
505-80-00 W88-70030
NASP-Hypersonics Research and Technology-Space
506-80-00 W88-70098

ARNOLD, M. C.
Information Sciences Research and Technology
505-65-00 W88-70015
Space Data Communications Research and Technology
506-44-00 W88-70068

ARNOLD, W.
Systems Analysis
506-49-00 W88-70094

ATKINS, KENNETH L.
Space Energy Conversion Research and Technology
506-41-00 W88-70050
High Capacity Power
586-01-00 W88-70134

ATKINS, P.
Fluid and Thermal Physics Research and Technology
505-60-00 W88-70004

ATKINSON, D.
Automation Techniques for Science Missions
450-14-01 W88-70393

B

BAGWELL, J. W.
Spectrum and Orbit Utilization Studies
643-10-01 W88-70407
Advanced Studies
643-10-05 W88-70411

BAGWELL, JAMES W.
Propagation Studies and Measurements
643-10-03 W88-70408
Space Communications Systems Antenna Technology
650-60-20 W88-70413
Satellite Switching and Processing Systems
650-60-21 W88-70414
Communications Laboratory for Transponder Development
650-60-23 W88-70415

BAILEY, C. R.
Science Sensor Technology
584-01-00 W88-70126

BAILEY, F. R.
Numerical Aerodynamic Simulation (NAS)
536-01-00 W88-70045
Numerical Aerodynamic Simulation (NAS) Operations and Management
536-02-00 W88-70046

BAILEY, H.
CSTI - Robotics
549-02-00 W88-70102
CSTI - Autonomous Systems
549-03-00 W88-70114

BAKER, WAYMAN
Satellite Data Assimilation
146-60-08 W88-70141
Programmatic Support
146-64-10 W88-70143
Meteorological Parameter Extraction
146-65-00 W88-70144

BALLARD, RODNEY W.
Extended Data Base Analysis
199-70-12 W88-70352

BARNES, A.
Magnetospheric Physics: Particles and Particle/Field Interaction
442-36-55 W88-70375

BARNWELL, R. W.
Interdisciplinary Technology
505-90-00 W88-70032

BASS, B. G.
Consulting and Program Support
674-29-08 W88-70487

BAUTISTA, J. J.
Radio Systems Development
310-20-66 W88-70585

BEACH, H.
NASP-Hypersonics Research and Technology-Aero
505-80-00 W88-70029
NASP-Hypersonics Research and Technology-Space
506-80-00 W88-70099

BELL, ROBIN
A Geobotanical, Geological, Geophysical Investigation of an Archean Subprovince Boundary (Quetico/Wabigoon) Using Remotely Sensed Data
677-43-27 W88-70536

BILLINGHAM, J.
Space Adaptation Syndrome
199-12-52 W88-70322
Cardiovascular Physiology
199-21-12 W88-70323

BLANCHARD, D. P.
Planetary Materials: Collection, Preservation, and Distribution
152-20-40 W88-70203

BLANKENSHIP, C. P.
Materials and Structures Research and Technology
505-63-00 W88-70010
Advanced Rotorcraft Technology
532-06-00 W88-70036
Advanced Turboprop Systems
535-03-00 W88-70041
Materials and Structures Research and Technology
506-43-00 W88-70058
Precision Segmented Reflectors
585-02-00 W88-70133

BLANKENSHIP, R. R.
Aerothermodynamics Research and Technology
506-40-00 W88-70047

BLANKENSHIP, R. V.
Applied Aerodynamics Research and Technology
505-61-00 W88-70005

BLOM, R. G.
Tectonics of Western Basin and Range
677-43-21 W88-70529

BOLDT, E. A.
X-Ray Astronomy
188-46-59 W88-70306
Sounding Rocket (Spartan) Experiments (High Energy Astrophysics)
879-11-46 W88-70571

BORUCKI, W. J.
Planetary Lightning and Analysis of Voyager Observations
154-90-80 W88-70218
High Precision Photometer
157-05-50 W88-70239

BOWMAN, G. H.
ATD Near Term Flight Hardware Definition
199-80-92 W88-70358

BRANDHORST, H. W.
Space Energy Conversion Research and Technology
506-41-00 W88-70052
System Analysis
506-49-00 W88-70090
CSTI - Autonomous Systems
549-03-00 W88-70115
High Capacity Power
586-01-00 W88-70135

BRODER, SOL
Computer Networking
656-31-01 W88-70426

BROWN, JAMES W.
Earth Science Applications Data Systems (ESADS) Support: Interoperations, Data Standards, and Implementation Coordination
656-50-05 W88-70442

BROWN, S. K.
Particle Accelerator Facility: Maintenance and Operation of a Calibration Facility for Magnetospheric and Solar-Terrestrial Experiments
442-36-57 W88-70379

BROWNE, I. DALE
Planetary Materials: Mineralogy and Petrology
152-11-40 W88-70192
Planetary Materials: Experimental Petrology
152-12-40 W88-70194

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

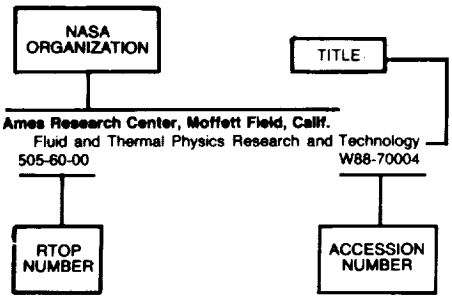
V

W

Y

Z

Typical Responsible NASA Organization Index Listing



Listings in this index are arranged alphabetically by Responsible NASA Organization. The title of the RTOP provides the user with a brief description of the subject matter. The accession number denotes the number by which the citation and the technical summary can be located within the Summary Section. The titles are arranged under each Responsible NASA Organization in ascending accession number order.

A

Ames Research Center, Moffett Field, Calif.

Fluid and Thermal Physics Research and Technology
505-60-00 W88-70004

Applied Aerodynamics Research and Technology
505-61-00 W88-70006

Materials and Structures Research and Technology
505-63-00 W88-70011

Information Sciences Research and Technology
505-65-00 W88-70015

Controls and Guidance Research and Technology
505-66-00 W88-70019

Human Factors Research and Technology
505-67-00 W88-70020

Flight Systems Research and Technology
505-68-00 W88-70023

Systems Analysis
505-69-00 W88-70027

NASP-Hypersonics Research and Technology-Aero
505-80-00 W88-70030

Interdisciplinary Technology
505-90-00 W88-70035

Advanced Rotorcraft Technology
532-06-00 W88-70037

High-Performance Flight Research
533-02-00 W88-70038

Advanced Turboprop Systems
535-03-00 W88-70042

Numerical Aerodynamic Simulation (NAS)
536-01-00 W88-70045

Numerical Aerodynamic Simulation (NAS) Operations and Management
536-02-00 W88-70046

Aerothermodynamics Research and Technology
506-40-00 W88-70048

Materials and Structures Research and Technology
506-43-00 W88-70060

Space Data Communications Research and Technology
506-44-00 W88-70068

Information Sciences Research and Technology
506-45-00 W88-70073

Controls and Guidance Research and Technology
506-46-00 W88-70079

Human Factors Research and Technology
506-47-00 W88-70081

Space Flight Research and Technology
506-48-00 W88-70087

Systems Analysis
506-49-00 W88-70094

NASP-Hypersonics Research and Technology-Space
506-80-00 W88-70098

CSTI - Robotics
549-02-00 W88-70102

CSTI - Autonomous Systems
549-03-00 W88-70114

Science Sensor Technology
584-01-00 W88-70126

Research and Technology
763-01-00 W88-70139

Stratosphere-Troposphere Exchange Project (STEP) Management
147-14-12 W88-70167

Quantitative Infrared Spectroscopy of Minor Constituents of the Earth's Stratosphere
147-23-01 W88-70175

Solar System Studies
151-01-60 W88-70187

Mars Exobiology Research Consortium
151-20-80 W88-70191

Planetary Materials: Carbonacious Meteorites
152-13-60 W88-70196

Planetary Atmospheric Composition, Structure, and History
154-10-80 W88-70205

Dynamics of Planetary Atmospheres
154-20-80 W88-70206

Planetary Clouds Particulates and Ices
154-30-80 W88-70208

Multi-Dimensional Model Studies of the Mars Ionosphere
154-60-80 W88-70212

Planetary Lightning and Analysis of Voyager Observations
154-90-80 W88-70218

Physical and Dynamical Models of the Climate on Mars
154-95-80 W88-70219

Planetary Instrument Definition and Development Program: Titan Atmospheric Analysis
157-04-80 W88-70237

High Precision Photometer
157-05-50 W88-70239

Study of Large Deployable Reflector for Infrared and Submillimeter Astronomy
159-41-01 W88-70244

Development of Space Infrared Telescope Facility (SIRTF)
159-41-06 W88-70246

Global Tropospheric Experiment Aircraft Measurements
176-20-99 W88-70282

Theoretical Studies of Galaxies, The Interstellar Medium, Molecular Clouds, Star Formation
188-41-53 W88-70296

Laboratory Study of Chemical and Physical Properties of Interstellar PAHs
188-41-57 W88-70298

Theoretical Studies of Active Galaxies and Quasi-Stellar Objects (QSOs)
188-46-01 W88-70300

Center for Star Formation Studies
188-48-52 W88-70307

Planetary Astronomy and Supporting Laboratory
196-41-67 W88-70320

Space Adaptation Syndrome
199-12-52 W88-70322

Cardiovascular Physiology
199-21-12 W88-70323

Neurophysiology
199-22-22 W88-70324

Bone Physiology
199-22-32 W88-70325

Muscle Physiology
199-22-42 W88-70327

Crew Productivity
199-22-62 W88-70329

Vestibular Research Facility (VRF)
199-22-92 W88-70331

Biospheric Monitoring and Disease Prediction
199-30-32 W88-70332

Biogeochemical Research in Tropical Ecosystems
199-30-62 W88-70334

Biogeochemical Research in Temperate Ecosystems
199-30-72 W88-70335

Gravity-Sensing Systems
199-40-12 W88-70339

Developmental Biology
199-40-22 W88-70340

Biological Adaptation: (A) Structure and Biomineralization; (B) Regulatory Mechanisms
199-40-32 W88-70341

Cosmic Evolution of Biogenic Compounds
199-52-12 W88-70342

Prebiotic Evolution
199-52-22 W88-70344

The Early Evolution of Life
199-52-32 W88-70346

Evolution of Advanced Life
199-52-42 W88-70347

Solar System Exploration
199-52-52 W88-70348

The Search for Extraterrestrial Intelligence (SETI)
199-52-62 W88-70349

Bioregenerative Life Support Research (CELSS)
199-61-12 W88-70350

Bioregenerative Life Support Flight Experiments and Tests
199-61-32 W88-70351

Extended Data Base Analysis
199-70-12 W88-70352

Data Analysis: Exobiology Planetary Data Studies and Life Science Data System Development
199-70-22 W88-70353

Data Analysis Techniques: Advanced Data Handling Studies for Life Sciences Flight Experiments
199-70-32 W88-70354

Development of Remote Sensing Instruments
199-80-00 W88-70355

Advanced Technology Development: Future Life Sciences Flight Experiments
199-80-82 W88-70357

ATD Near Term Flight Hardware Definition
199-80-92 W88-70358

Tethered Artificial Gravity Research Facility Study
199-90-67 W88-70359

Ames Research Center Initiatives: Life Science Overguideline
199-90-72 W88-70360

Magnetospheric Physics: Particles and Particle/Field Interaction
442-36-55 W88-70375

Space Station Life Sciences Operations
450-11-02 W88-70387

Space Station Payload Analysis and Trade Studies
450-15-02 W88-70397

Space Station Life Sciences Enabled Science
450-16-02 W88-70401

Human-Rated Centrifuge Study
450-16-12 W88-70402

Testbedding for Telescience, Teleoperation, and Teledesign
450-17-02 W88-70406

Pilot Land Data System (PLDS)
656-13-50 W88-70423

Aerosol and Gas Measurements Addressing Aerosol Climatic Effects
672-21-02 W88-70452

Fire-cloud Radiation Research
672-22-13 W88-70454

Aerosol Formation Models
672-31-02 W88-70456

Climate Modeling Assessment
672-32-01 W88-70459

Ames Multi-Program Support for Climate Research
672-50-01 W88-70460

Analysis of Troposphere-Stratosphere Exchange
673-42-01 W88-70468

Stratospheric Dynamics and Particulates
673-61-03 W88-70470

Global Biodiversity: Habitat Change and Species Extinctions
677-21-00 W88-70500

Forest Evapotranspiration and Production
677-21-31 W88-70505

Image Processing Laboratory for Terrestrial Ecology
677-21-34 W88-70507

Biogeochemical Cycling in Terrestrial Ecosystems
677-21-35 W88-70508

Optical Scattering of Plant Canopies
677-24-01 W88-70520

G

Goddard Inst. for Space Studies, New York.

Investigation of Comparative Planetary Dynamics
154-20-80 W88-70207

Radiative Transfer in Planetary Atmospheres
154-40-80 W88-70209

ORGANIZATION

Goddard Space Flight Center, Greenbelt, Md.

General Circulation and Chemistry
673-64-00 W88-70474
Solid Earth Dynamics
676-10-10 W88-70488
Solar Radius/Luminosity Studies
676-40-02 W88-70490
Software Development Support
676-40-10 W88-70491
Geopotential Research Mission (GRM)
676-59-10 W88-70492
Laser Ranging Development Study
676-59-32 W88-70495
Magnolia/Magnetic Field Explorer
676-59-80 W88-70499
Terrestrial Ecosystems
677-21-24 W88-70503
Global Inventory Monitoring and Modeling Experiment
677-21-32 W88-70506
Basic Land System Studies
677-21-36 W88-70509
Studies of the Influence of Anomalies in the Biosphere on Climate
677-21-37 W88-70511
Forest Ecosystem Dynamics
677-21-40 W88-70512
Hydrologic Information Extraction Technique Development
677-22-27 W88-70514
Water Resources Cycling (ISLSCP)
677-22-28 W88-70515
First ISLSCP Field Experiment (FIFE)
677-22-29 W88-70516
Remote Sensing Science Program
677-24-01 W88-70519
Continental Accretion
677-43-23 W88-70530
Topographic Profile Analysis
677-43-24 W88-70531
East African Rift Tectonics and Volcanics
677-43-25 W88-70533
A Geobotanical, Geological, Geophysical Investigation of an Archean Subprovince Boundary (Quetico/Wabigoon) Using Remotely Sensed Data
677-43-27 W88-70536
Sources of Magnetic Anomaly Field
677-45-03 W88-70537
Determination and Inversion of Crustal Magnetic Fields
677-45-06 W88-70538
Magnetic Properties of Crustal Materials
677-45-09 W88-70539
Program Development (GSFC)
677-80-80 W88-70549
IDS Land Climatology Program
677-92-00 W88-70550
Crustal Dynamics
692-30-00 W88-70554
Lageos 2 (International Cooperative Project)
693-70-00 W88-70564
Crustal Dynamics
693-90-10 W88-70565
Sounding Rocket Experiments
879-11-38 W88-70569
Sounding Rocket Experiments (Astronomy)
879-11-41 W88-70570
Sounding Rocket (Spartan) Experiments (High Energy Astrophysics)
879-11-46 W88-70571
Software Engineering Technology
310-10-23 W88-70573
Flight Dynamics Technology
310-10-26 W88-70574
Network Systems Technology Development
310-20-33 W88-70579
Network Communications Technology
310-20-38 W88-70580
Very Long Baseline Interferometry (VLBI) Tracking of the Tracking and Data Relay Satellite (TDRS)
310-20-39 W88-70581
Advanced Space Systems for Users of NASA Networks
310-20-46 W88-70582
Human-To-Machine Interface Technology
310-40-37 W88-70590
Expert Systems for Automation of Operations
310-40-44 W88-70591
Mission Operations Technology
310-40-45 W88-70592
Data Storage Technology
310-40-46 W88-70593
Systems Engineering and Management Technology
310-40-49 W88-70594

J

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

Fluid and Thermal Physics Research and Technology
505-60-00 W88-70003
Applied Aerodynamics Research and Technology
505-61-00 W88-70007
Space Energy Conversion Research and Technology
506-41-00 W88-70050
Propulsion Research and Technology
506-42-00 W88-70057
Materials and Structures Research and Technology
506-43-00 W88-70059
Space Data and Communications Research and Technology
506-44-00 W88-70070
Information Sciences Research and Technology
506-45-00 W88-70072
Controls and Guidance Research and Technology
506-46-00 W88-70080
Human Factors Research and Technology
506-47-00 W88-70083
Systems Analysis
506-49-00 W88-70095
CSTI - Robotics
549-02-00 W88-70104
CSTI - Autonomous Systems
549-03-00 W88-70113
Science Sensor Technology
584-01-00 W88-70127
Data: High Rate/Capacity
584-02-00 W88-70129
Precision Segmented Reflectors
585-02-00 W88-70132
High Capacity Power
586-01-00 W88-70134
Meteorological Parameters Extraction
146-66-01 W88-70145
Global Seasat Wind Analysis and Studies
146-66-02 W88-70146
Program Support
146-66-04 W88-70147
Interagency Temperature Sounder (ITS)
146-72-00 W88-70149
Microwave Pressure Sounder
146-72-01 W88-70150
IR Remote Sensing of SST
146-72-03 W88-70151
Tropospheric Wind Measurement Assessment
146-72-04 W88-70152
AMSU Research Studies
146-72-05 W88-70153
Atmospheric Parameter Mapping
146-72-06 W88-70154
Atmospheric Dynamics and Radiation Science Support
146-72-09 W88-70155
Lidar Target Calibration Facility
146-72-10 W88-70156
Atmospheric Backscatter Experiment
146-72-11 W88-70157
Diode Laser
147-11-07 W88-70159
Infrared Radiometry
147-12-05 W88-70161
Millimeter and Submillimeter Radiometry
147-12-06 W88-70162
Far Infrared Balloon Radiometer for OH
147-12-15 W88-70163
Dial System for Stratospheric Ozone 3
147-13-15 W88-70164
Altitude Temperature Profiles
147-14-07 W88-70166
Multi-Sensor Balloon Measurements
147-16-01 W88-70169
Chemical Kinetics of the Upper Atmosphere
147-21-03 W88-70172
Photochemistry of the Upper Atmosphere
147-22-01 W88-70173
Atmospheric Photochemistry
147-22-02 W88-70174
Infrared Laboratory Spectroscopy in Support of Stratospheric Measurements
147-23-08 W88-70176
Laser Laboratory Spectroscopy
147-23-09 W88-70177
Millimeter/Submillimeter Laboratory Spectroscopy
147-23-10 W88-70178
Data Survey and Evaluation
147-51-02 W88-70180
Interdisciplinary Science Support
147-51-12 W88-70181
Detailee/Upper Atmosphere Research Program
147-52-01 W88-70182
Planetology
151-01-70 W88-70188
Experimental Studies on Meteorites
152-17-70 W88-70200
Planetary Data System and Coordination
155-20-70 W88-70220
Mars Data Analysis
155-50-70 W88-70221
International Halley Watch
156-02-02 W88-70223
Giotto: Ion Mass Spectrometer, Co-Investigator Support
156-03-03 W88-70225
Giotto PIA Co-Investigator Support
156-03-04 W88-70227
Giotto DIDSY Co-Investigator Support
156-03-07 W88-70229
Phobos Lander Dynamics Science Team
156-03-80 W88-70230
Advanced CCD Camera Development
157-01-70 W88-70232
MM2 Imaging
157-03-70 W88-70234
Diode Laser IR Absorption Spectrometer
157-04-80 W88-70236
A Study of the Large Deployable Reflector (LDR) for Astronomy Applications
159-41-01 W88-70243
Optical Interferometry in Space
159-41-02 W88-70245
Astrophysical CCD Development
159-60-78 W88-70249
Advanced Scatterometry
161-10-08 W88-70251
Determination of the EM Bias in Ocean Altimetry
161-20-00 W88-70252
Currents/Tides from Altimetry
161-20-07 W88-70253
Ocean Productivity
161-30-02 W88-70257
Plankton Fluorescence and Productivity
161-30-05 W88-70258
West Coast Satellite Data Visualization
161-30-19 W88-70259
Active/Passive Sea Ice Analysis
161-40-02 W88-70260
Detailee/Njoku
161-40-03 W88-70261
NASA Ocean Data System (NODS)
161-40-10 W88-70263
ERS-1 SAR
161-40-11 W88-70264
NASA/NOAA Satellite Oceanography
161-40-30 W88-70265
Oceanic Remote Sensing Library
161-50-02 W88-70266
Ocean Processes Branch Scientific Program Support
161-50-03 W88-70267
Analysis of Oceanic Productivity
161-50-07 W88-70269
JPL Oceanography Group Plan for a Common Computer System
161-60-15 W88-70270
Remote Sensing of Air-Sea Fluxes
161-80-15 W88-70271
Theoretical/Numerical Study of the Dynamics of Ocean Waves
161-80-37 W88-70272
Ocean Circulation and Satellite Altimetry
161-80-38 W88-70273
Scatterometer Research
161-80-39 W88-70274
Studies of Sea Surface Topography and Temperature
161-80-40 W88-70275
Effects of Large-Scale Wave-Field Component on Remote Sensing Measurements of Wind and Waves
161-80-41 W88-70276
Large Scale Air-Sea Interactions
161-80-42 W88-70277
Space Oceanography
161-80-43 W88-70278
Data Assimilation and Ocean General Circulation Model
161-80-44 W88-70279
Ultrasound Detection of Bends
199-11-34 W88-70321
Bone Loss
199-22-34 W88-70326
Muscle Physiology
199-22-44 W88-70328
Radiation Effects and Protection
199-22-74 W88-70330
Biospheric Monitoring and Disease Prediction
199-30-32 W88-70333
Organic Chemistry of Comets
199-52-14 W88-70343

L

M

N

W

Typical RTOP Number Index Listing

This section may be used to identify the RTOP accession number of reports covered in this journal. Thus this section of this index may be used to locate the bibliographic citations and technical summaries in the Summary Section. The RTOP numbers are listed in ascending number order.

C-3

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM-89662		

4. Title and Subtitle	5. Report Date
Research and Technology Objectives and Plans Summary Fiscal Year 1988	January 1988
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
	10. Work Unit No.
9. Performing Organization Name and Address National Aeronautics and Space Administration Washington, DC 20546	11. Contract or Grant No.
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This publication represents the NASA research and technology program for FY 1988. It is a compilation of the "Summary" portions of each of the RTOPs (Research and Technology Objectives and Plans) used for management review and control of research currently in progress throughout NASA. The RTOP Summary is designed to facilitate communication and coordination among concerned technical personnel in government, in industry, and in universities. The first section containing citations and abstracts of the RTOPs is followed by four indexes: Subject, Technical Monitor, Responsible NASA Organization, and RTOP Number.

17. Key Words (Suggested by Authors(s))	18. Distribution Statement
Physical Sciences Project Management Research and Development Aerospace Science Life Sciences	[redacted] Until January 1990 Subject Category 99

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price *
Unclassified	Unclassified	192	A09

NASA-Langley, 1988